79/29

Series II Multimeter

Service Manual

FLUKE®

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PN 896209
Date July 1991 Rev.3, 12/95

FLUKE®

OPERATOR SAFETY INFORMATION

This meter has been designed and tested according to IEC Publication 1010-1. Follow all safety and operating instructions to ensure that the meter is used safely and is kept in good operating condition.

- Never use the meter if the meter or test leads look damaged.
- Always turn off power to the circuit before cutting, unsoldering, or breaking the circuit. Small amounts of current can be dangerous.
- Never measure resistance in a circuit when power is applied to the circuit.
- Never touch the probes to a voltage source when the test leads are plugged into the 10A or 40 mA input jack.
- To avoid damage or injury, never use the meter on unprotected circuits that exceed 14000 volt-amps.
- Never apply more than 600V dc or ac rms (sine) between any input jack and earth ground.
- Always be careful when working with voltages above 60V dc or 30V ac rms. Such voltages pose a shock hazard.
- Always keep your fingers behind the finger guards on the probe when making measurements.
- Always use a high voltage probe to measure voltage if the peak voltage might exceed 600V.

SYMBOLS MARKED ON EQUIPMENT

DANGER - High voltage.

Attention - refer to the manual. This symbol indicates that information about usage of a feature is contained in the manual.

Fuse information.

USE THE PROPER FUSE

To avoid fire hazard, use only a fuse identical in type, voltage rating, and current rating as specified on the case bottom fuse rating label.

DO NOT OPERATE DISASSEMBLED METER

Always operate the meter with case top and bottom properly assembled.

Access procedures and the warnings for such procedures are contained in this Service Manual. Service procedures are for qualified service personnel only.

DO NOT ATTEMPT TO OPERATE IF PROTECTION MAY BE IMPAIRED

If the meter appears damaged or operates abnormally, protection may be impaired. Do not attempt to operate it. When in doubt, have the meter serviced.

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Chapter 1
Introduction and Specifications

Introduction 1-1.

This service manual provides information on maintaining, troubleshooting, and repairing the Fluke 79 and 29 Multimeters. The manual also provides specifications, theory of operation, calibration routines, testing and troubleshooting procedures, parts replacement information, and schematic diagrams.

A meter under warranty will be promptly repaired or replaced (at Fluke's option) and returned at no charge. See the registration card for warranty terms. If the warranty has expired, the meter will be repaired and returned for a fixed fee. Contact the nearest Service Center for information and prices. A list of U.S. and International Service Centers is included at the end of Chapter 4 of this manual.

Organization of the Service Manual 1-2.

The following descriptions for the various chapters serve to introduce the manual.

Chapter 1. Introduction and Specifications

This chapter describes both use of the Service Manual and application of special terminology (conventions) to describe the meter's circuitry. A complete set of specifications appears at the end of this chapter.

Chapter 2. Theory of Operation

This chapter first categorizes instrument circuitry into functional blocks, with a description of each block's role in overall operation. A detailed circuit description is then given for each block. These descriptions explain operation to the component level and support the troubleshooting and repair procedures defined in Chapter 3.

Chapter 3. Maintenance

This chapter provides complete maintenance information ranging from general maintenance, cleaning instructions, and detailed troubleshooting to repair procedures involving component-level adjustments. Troubleshooting and repair procedures rely heavily on both the Theory of Operation presented in Chapter 2 and the Schematic Diagrams shown in Chapter 5.

Chapter 4. List of Replaceable Parts

The chapter includes parts lists for all standard assemblies. Information on how and where to order parts is also provided.

Chapter 5. Schematic Drawings

This chapter provides a schematic diagram for the main pca.

Conventions 1-3.

Throughout the manual, certain notational conventions are used. A summary of these conventions follows:

- Printed Circuit Assembly

  The term "pca" is used to represent a printed circuit board and its attached parts.

- Circuit Nodes

  Individual pins or connections on a component are specified by a dash (-) following the component reference designator. For example, pin 19 of U30 would be U30-19.

- User Notation

  Generally, function switch positions to select, input terminals to use, and display notation to be read are presented in this manual as they are seen on the multimeter.

  Special terms (mnemonics) used in text descriptions of multimeter circuitry correspond to terms used on the schematic diagrams in 5.

Specifications 1-4.

Specifications for Models 79 and 29 are presented in Table 1-1.

Accuracy is specified for a period of one year after calibration, at 18°C to 28°C (64°F to 82°F) with relative humidity to 90%. AC conversions are ac-coupled, average responding, and calibrated to the rms value of a sine wave input.

Accuracy Specifications are given as:

±([% of reading] + number of least significant digits)

Table 1-1. Specifications

Maximum Voltage Between any Terminal and Earth Ground:	1000V dc, 750V ac rms(sine)
Fuse Protection:	40 mA: 1A 600V FAST Fuse 10A: 15A 600V FAST Fuse
Display:	Digital: 4000 counts, update rate 4/sec Analog: 63 segments, updates 40/sec Frequency: 9,999 counts Capacitance: 9,999 counts
Operating Temperature:	0°C to 55°C
Storage Temperature:	-40°C to 60°C
Temperature Coefficient:	0.1 x (specified accuracy)/°C (<18°C or >28°C)
EMC:	In an RF field of 1 V/m on all ranges and functions: Total Accuracy = Specified Accuracy + 0.5% of range Performance above 1 V/m is not specified
Relative Humidity:	0% to 90% (0°C to 35°C) 0% to 70% (35°C to 55°C)
Battery Type:	9V, NEDA 1604 or 6F22 or 006P
Battery Life:	700 hrs typical with alkaline 500 hrs typical with carbon zinc
Continuity Beeper:	4096 Hz
Shock, Vibration:	Per MIL-T-28800 for a Style B, Class 2 Instrument
Size (HxWxL):	1.12 in x 2.95 in x 6.55 in (2.8 cm x 7.5 cm x 16.6 cm)
Weight:	12 oz (340g)
Safety:	Designed to Protection Class II per IEC 348, ANSI/ISA-S82, UL1244, and CSA C22.2 No.231

Table 1-1. Specifications (cont)

FUNCTION	RANGE	RESOLUTION	ACCURACY	BURDEN VOLTAGE (TYPICAL)
VAC	400.0 mV	0.1 mV	±(1.9%+4)	
(45 Hz to1 kHz)	4.000V	0.001V	±(1.9%+2)	
	40.00V	0.01V	±(1.0%+2)	Not Applicable
	400.0V	0.1V	±(1.0%+2)	
	750V	1V	±(1.0%+2)	
To 20 kHz			±1.5 dB typical	
VDC	4.000V	0.001V	±(0.3%+1)	
	40.00V	0.01V	±(0.3%+1)	Not Applicable
	400.0V	0.1V	±(0.3%+1)	
	1000V	1V	±(0.3%+1)	
mVDC	40.00 mV	0.01 mV	±(0.3%+5)	Not Applicable
	400.0 mV	0.1 mV	±(0.3%+1)	
Ω	400.0Ω	0.1Ω	±(0.4%+2)	
	4.000 kΩ	0.001 kΩ	±(0.4%+1)	
	40.00 kΩ	0.01 kΩ	±(0.4%+1)	Not Applicable
	400.0 kΩ	0.1 kΩ	±(0.4%+1)	
	4.000 MΩ	0.001 MΩ	±(0.4%+1)	
	40.00 MΩ	0.01 MΩ	±(1%+3)	
Capacitance	99.99 nF	0.01 nF	±(1.9%+2)[1]	
	999.9 nF	0.1 nF	±(1.9%+2)[1]	
	9.999 µF	0.001 µF	±(1.9%+2)[1]	Not Applicable
	99.99 µF	0.01 µF	±(1.9%+2)[1]	
	999.9 µF	0.1 µF	±(1.9%+2)[1]	
	9999 µF	1 µF	±10% typical	
)))	400Ω	0.1Ω	5% typical	Not Applicable
40Ω	40Ω	0.01Ω	5% typical	
(Lo-Ohms)	400Ω	0.1Ω	5% typical	Not Applicable
	8 kΩ	1Ω	10% typical	
Diode Test	2.450V	0.001V	±2% typical	Not Applicable
AAC	4.000 mA	0.001 mA	±(1.5%+4)	11 mV/mA
(45 Hz to1 kHz)	40.00 mA	0.01 mA	±(1.5%+2)	11 mV/mA
	4A	0.001A	±(1.5%+4)	0.03 V/A
	10.00 A[2]	0.01A	±(1.5%+2)	0.03 V/A

Table 1-1. Specifications (cont)

FUNCTION	RANGE	RESOLUTION	ACCURACY	BURDEN VOLTAGE (Typical)
ADC	4.000 mA	0.001 mA	±(0.5%+5)	11 mV/mA
	40.00 mA	0.01 mA	±(0.5%+2)	11 mV/mA
	4A	0.001A	±(0.5%+5)	0.03 V/A
	10.00 A[2]	0.01A	±(0.5%+2)	0.03 V/A
Frequency[3]	99.99	0.01 Hz	±(0.01%+1)	
(1 Hz to 20 kHz)	999.9	0.1 Hz	±(0.01%+1)	Not Applicable
	9.999 kHz	0.001 kHz	±(0.01%+1)	
	20.00 kHz	0.01 kHz	±(0.01%+1)	
	20.00-99.99	9 kHz ±0.01 kHz	Usable	
	>99.99 kHz	0.1 kHz	Usable	

FREQUENCY COUNTER SENSITIVITY AND TRIGGER LEVEL		
Input Range[4]	Minimum Sensitivity (RMS Sine Wave)	
	500 Hz to 20 kHz	1.0 Hz to 500 Hz[5]
400 mV ac	150 mV	500 mV
4V ac	0.3V	0.7V
40V ac	3V	7V
400V ac	30V	70V
750V ac	300V	700V

Table 1-1. Specifications (cont)

FUNCTION	OVERLOAD PROTECTION+	INPUT IMPEDANCE (NOMINAL)	COMMON MODE REJECTION RATIO (1 KΩ UNBALANCE)		NORMAL MODE REJECTION
VDC	1000V dc 750V ac rms (sine)	>10 MΩ, <100 pF	>120 dB at dc, 50 Hz, or 60 Hz		>60 dB at 50 Hz or 60 Hz
mVDC	1000V dc 750V ac rms (sine)	10 MΩ, <100 pF	>120 dB at dc, 50 Hz, or 60 Hz		>60 dB at 50 Hz or 60 Hz
VAC	1000V dc[6] 750V ac rms (sine)	>10 MΩ, <100 pF (ac-coupled)	>60 dB, dc to 60 Hz		
Ω	500V dc, 500V rms (sine)	**Open Circuit Test Voltage**	**Full Scale Voltage**		**Short Circuit Current**
			To 4.0 MΩ	40 MΩ	
		<1.3V dc	<450 mV dc	<1.3V dc	<500 µA
→|←	500V dc, 500V rms (sine)	<3.1V dc	2.45V dc	--	800 µA typical

NOTES

[1] With film capacitor or better and open lead reading subtracted from measurement. This meter uses a dc-type measurement technique.

[2] 10A continuous, 20A for 30 seconds maximum.

[3] For rectangular waveforms 25% ≤ duty cycle ≤ 75%.

[4] Maximum input for specified accuracy = 10 x Range or 750V.

[5] Display rattle for sine wave below 500 = 5 counts.

[6] 10^7 V-Hz max.

Chapter 2
Theory of Operation

Introduction 2-1.

This chapter describes the theory of operation for the Fluke 79 and Fluke 29 Multimeters. Unless otherwise specified, the descriptions apply to both instruments.

Functional block descriptions present an overview of circuit operation followed by circuit descriptions, which detail the major circuit functions. Schematic diagrams are provided in Chapter 5.

Functional Block Description 2-2.

The instrument is partitioned into analog and digital chapters. (See Figure 2-1 Block Diagram.) The integrated multimeter chip (U4) performs both analog and digital functions, which are explained in more detail below.

The analog section of U4 contains the a/d converter, active filter, ac converter, frequency comparator, analog signal routing, range switching, and power supply functions.

The digital chapter of U4 executes software functions, formats data for the display, drives the display, and controls most analog and digital logic functions. The push button initiates various operating modes for the meter. Output from the digital chapter can be viewed on the liquid crystal display (LCD) and is audible through the beeper.

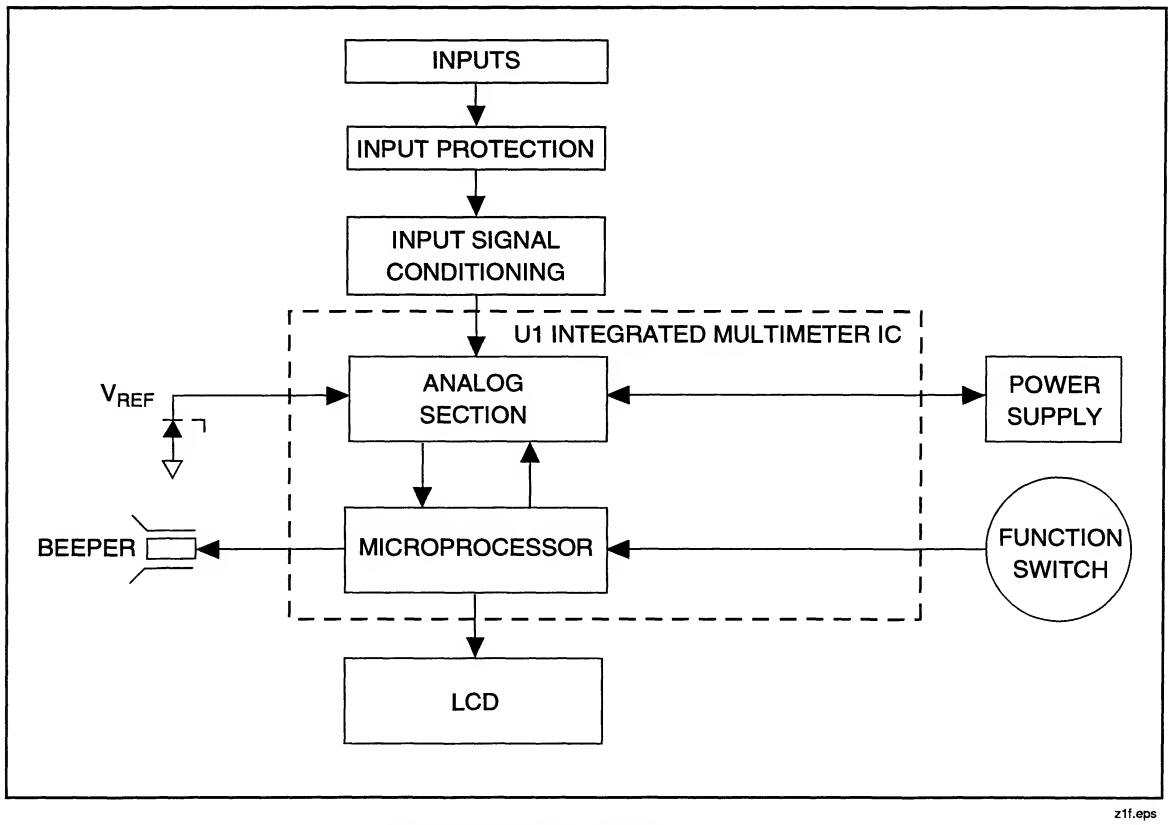


Figure 2-1. Block Diagram

Circuit Descriptions 2-3.

The following paragraphs discuss the functional blocks in Figure 2-1. Consult the schematic diagrams, located in Chapter 5, for additional circuit details not provided in this chapter.

Input Overload Protection 2-4.

The VΩ→⊢ input is protected from overload by a network consisting of two metal-oxide varistors (RV1 and RV2), three current-limiting resistors (R1, R2, and RT1), and spark gap E1. The presence of an extremely high energy signal causes R1 (1 kΩ, 2W), a fusible resistor, to open. Thermistor RT1 rises to a high impedance during a sustained voltage overload in the millivolts dc, ohms, or continuity mode. Transistors Q1 and Q2 form a voltage clamp network. This clamp performs a circuit limiting function on the overload current to U4 at 10 mA during ohms and continuity overloads. Power supply regulation and system operation is maintained during any of these overloads.

The mA input is protected from overloads by F1 (1A/600V), while F2 (15A/600V) protects the A input. Milliamp shunt resistor R5 is protected from overload currents below the F1 fusing level by the U1 and CR1 diode clamp network.

Rotary Knob Switch 2-5.

Input signals are routed from the overload protection circuits to a double-sided switch wafer. This switch wafer provides the necessary connections to implement signal conditioning and function-encoding for U4.

Input Signal Conditioning Circuits 2-6.

Each input signal is routed through signal conditioning circuitry before reaching multimeter chip U4. Incoming signals received through the VΩ→⊢ input are routed to precision resistor network Z1. This divider network precisely scales the input for the various voltage ranges and provides precision reference resistors that are used for the ohms and capacitance functions.

Input divider Z1 is used in two modes, series and parallel. In volts functions, a series mode provides four divider ratios. In the ohms function, a parallel mode provides five reference resistors. During the following discussion, refer to schematic and signal flow diagrams in Chapter 5.

Volts Functions 2-7.

In volts functions, signal flow for input divider Z1 begins with a voltage that appears at the VΩ→⊢ input. (See Figure 2-2, 4V Range Simplified Schematic.) This input is connected to the high end of the 9.996 MΩ resistor (Z1-1) through R1 and RT1. If the AC volts function is selected, dc blocking capacitor C1 is also connected in series. If the DC volts function is selected, C1 is shorted by S1 (contacts 6 and 7).

Internal switches connect the 9.996 MΩ and 1.1111 MΩ resistors (Z1-2 and -3). The low end of the 1.1111 MΩ resistor (Z1-7) is connected to the COM input through S1 contacts 11 and 12. This produces the divide-by-10 ratio needed for the 400 mV ac, 4V ac, and 4V dc ranges. The 400 mV ac and 4V ac ranges require frequency compensation, which is supplied by C20 (not shown in Figure 2-2.)

For the 40V range, internal switches connect the Z1-4 (101.01 kΩ) resistor to provide a divide-by-100 ratio. In the 400V range, Z1-5 (10.01 kΩ) produces a divide-by-1,000 ratio. And in the 1000V range, the Z1-6 (1.0001 kΩ) resistor provides a divide-by-10,000 ratio.

Ohms Functions *2-8.*

When the 400-ohm range is selected, internal switches connect the resistor Z1-2 (9.996 MΩ) to resistor Z1-6 (1.0001 kΩ). (See Figure 2-3, 400-Ohm Range Simplified Schematic.) Then through switch contacts S1 6, 7, and 9, these resistors form a reference resistor of 1 kΩ.

The source voltage is connected internally at both V0 and V4 of U4. The current is routed through two parallel resistors Z1-6 and Z1-2 (1.0001 kΩ and 9.996 MΩ), into S1 at contacts 6 and 9. The signal then travels out of S1 at contact 7, through R1 and RT1 and to the **VΩ→+** input. The signal then goes through the unknown resistance, and back to the COM input. The same current flows through the unknown resistance and the reference resistor. The voltage dropped across the unknown resistance is sensed from the **VΩ→+** input jack through R2 and S1 (contacts 2 and 3) to OVS of U4.

The a/d converter senses the voltage drop across the 1 kΩ reference resistor through the low (RRS of U4 through R13) and high (V0 and V4) points. These two voltages are used by the a/d converter to perform a ratiometric measurement. Since the same current flows through the reference and unknown resistors, the ratio of the resistance values is the same as the ratio of the voltage drops across them.

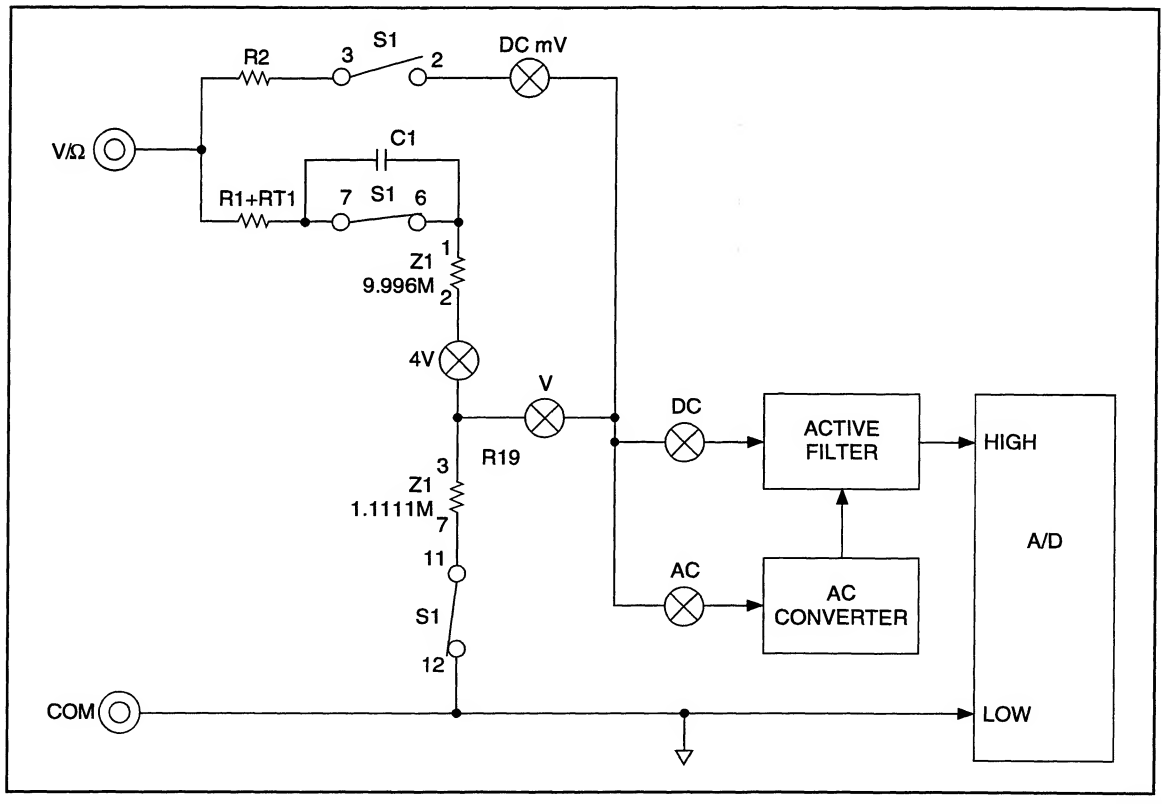


Figure 2-2. 4V Range Simplified Schematic

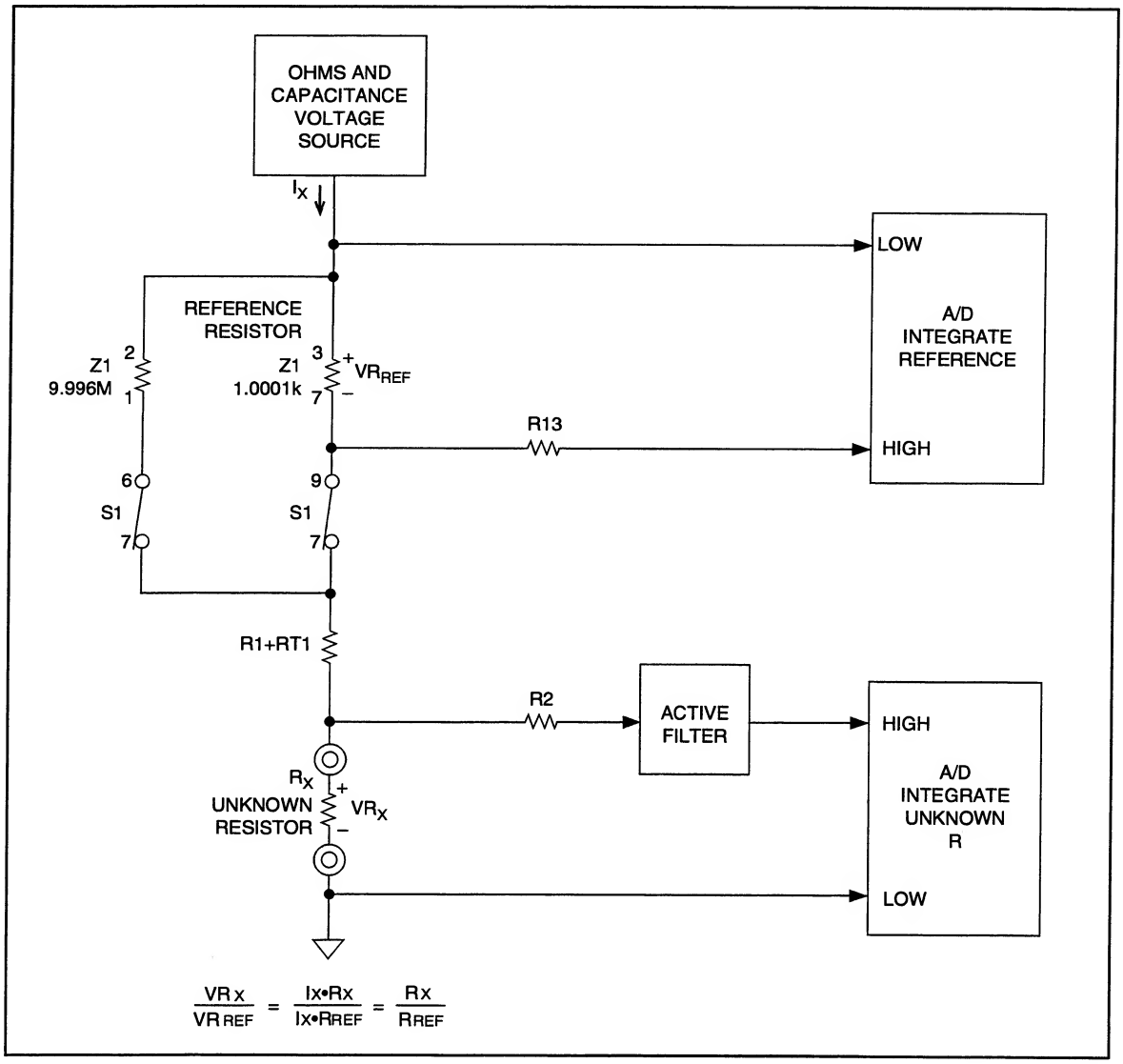


Figure 2-3. 400Ω Range Simplified Schematic

For the 4 kΩ range, the 10.010 kΩ resistor (Z1-5) used in parallel with the 9.996 MΩ resistor (Z1-2) forms a 10 kΩ reference resistor. For the 40 kΩ range, 101.01 kΩ (Z1-4) and 9.996 MΩ form a 100 kΩ reference resistor. And for the 400 kΩ range, 1.1111 MΩ (Z1-3) and 9.996 MΩ provide a 1 MΩ reference resistor. The 4 MΩ and 40 MΩ ranges use the 9.996 MΩ resistor alone.

Current Functions *2-9.*

Input current through R5+R6 (for mA) or R6 (for amps) develops a voltage that is proportional to the input. The dc voltage is routed to the active filter and a/d converter inside U4. The ac voltage is routed to the ac buffer, ac converter, active filter, and a/d converter. The 4 mA dc and 4A dc ranges use the a/d converter 40 mA range. The 4 mA ac and 4A ac ranges use the times 10 ac buffer range.

Continuity, Low Ohms and Diode Test Functions *2-10.*

Q13 provides the source current for the continuity, low ohms and diode test functions. Inputs are sensed through R2. R2 and R62 form a 10:1 divider for measuring voltages in diode test and the 8 kΩ range of low ohms. The continuity function is the 400Ω range of low ohms, and uses a comparator to turn on the beeper when the input drops below about 30Ω. Low ohms makes voltage measurements of the input to provide the higher resolution readings of the 40Ω range. Diode test also makes voltage measurements of the input. A single beep sounds when the input drops below about 0.75v; a continuous tone sounds for inputs below about 60 mV.

Analog Section Of Integrated Multimeter IC (U4) *2-11.*

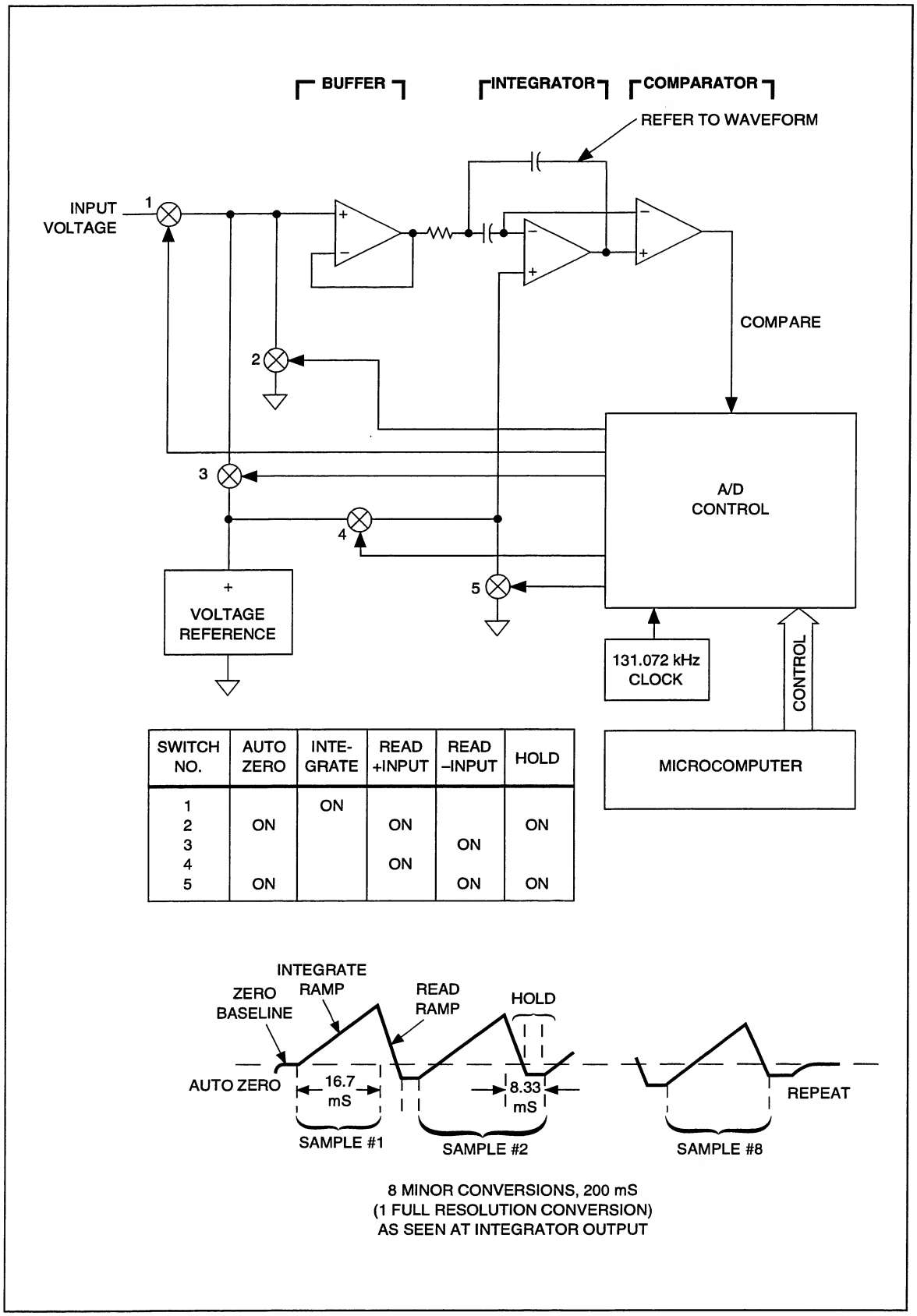
The a/d converter, autorange switching, frequency comparator, and most of the remaining analog circuitry are contained in the analog section of U4. Peripherals to this U4 analog section include the crystal clock, the system reference voltage, and the filter and amplifier resistors and capacitors.

U4 uses the dual-rate, dual-slope a/d converter circuit shown in Figure 2-4, A/D Converter. For most measurements, the basic a/d conversion cycle is 25 ms, for a rate of 40 measurements per second. A single conversion at this rate is called a minor cycle sample. Each minor cycle sample is used to provide updates at a rate of 40 per second for the fast response bar graph display, and fast autoranging.

Eight minor cycle samples are necessary to accumulate data for displaying a full-resolution (4000-count full scale) measurement on the digital display. A 40 ms autozero phase occurs following every eight-sample sequence. Therefore, each digital display update requires 240 ms, approximating four updates per second.

Basic a/d conversion elements and waveforms are illustrated in Figure 2-4, A/D Converter. A voltage level proportional to the unknown input signal charges (integrates) integrator capacitor C11 for an exact amount of time. This capacitor is then discharged by a reference voltage of opposite polarity. The discharge time, which is proportional to the level of the unknown input signal, is measured by the digital circuits in U4 and sent to the display.

Basic timing for the a/d converter is defined as a series of eight integrate and read (de-integrate) cycles, followed by a 40 ms autozero phase. However, the 40 MΩ, capacitance, overload recovery, autoranging, and Touch Hold® modes all require variations from the basic timing.



SWITCH NO.	AUTO ZERO	INTE-GRATE	READ +INPUT	READ -INPUT	HOLD
1		ON			
2	ON		ON		ON
3				ON	
4			ON		
5	ON			ON	ON

z4f.eps

Figure 2-4. A/D Converter

Capacitance Measurements 2-12.

Refer to Figure 2-5, 100-nF Range Simplified Schematic. Capacitance measurements to 10,000 µF are made by measuring the charge required to change the voltage across the unknown capacitor from zero to the system reference voltage. This technique is referred to as a ballistic type of measurement, the configuration of which is the same as for ohms. The unknown capacitor is discharged through the 1.0001 kΩ resistor of Z1, then charged during the a/d converter integrate cycle through the appropriate Z1 resistor. The voltage drop across the Z1 resistor is integrated by the a/d converter. During the a/d read cycle, the charge is held on the capacitor, and a count is accumulated. The microcomputer calculates a display value from the latched count, the capacitor is discharged, and the cycle repeats.

Frequency Measurements 2-13.

A voltage comparator is used for both signal detection in frequency mode and threshold detection in continuity mode. In frequency mode, digital pulses from the voltage comparator are routed to the counter. Pressing the range push button while in frequency mode causes a range change in the primary function (ac volts) that may change the sensitivity.

Microcomputer Control 2-14.

A microcomputer, integrated within U4, controls the various instrument functions and drives the display. The position of the rotary switch, S1, is decoded by the microcomputer from the three inputs F0, F1, and F2. All function modes, input ranging, signal routing, active filter enable, a/d timing and mode are controlled by the microcomputer.

The Touch Hold mode is a secondary software function. This means that the microcomputer performs a different control algorithm on the data. When the Touch Hold function is selected, the microcomputer does not allow a full resolution conversion to be completed unless the input signal is stable. When a stable reading occurs, the conversion is completed, and the microcomputer generates and freezes the corresponding display. The microcomputer now waits for a change in the signal to exceed a certain threshold, then begins watching for a stable reading again. Note that a reading is forced when the Touch Hold function is first selected. Also, open test lead signals generally do not update the display.

The SMOOTHING™ mode is another secondary software function. In the Smoothing function, the equivalent of eight readings are averaged, resulting in a more stable display of noisy input signals.

Peripherals To U4 2-15.

In addition to input overload protection and input signal conditioning circuits, other devices peripheral to U4 are needed to support the meter's features. The ac converter, active filter, and a/d converter circuits require off-chip resistors and capacitors. Digital drive and level-shifting circuits are needed for the beeper drive. A voltage reference is generated separate from U4, and some discrete resistors and transistors support the power supply.

AC Buffer 2-16.

The ac buffer can be configured for an ac gain of 1 or 10. R14 and R15 provide for the X10 gain. C5 blocks any dc gain and provides a driven guard voltage. The ac buffer drives the frequency comparator.

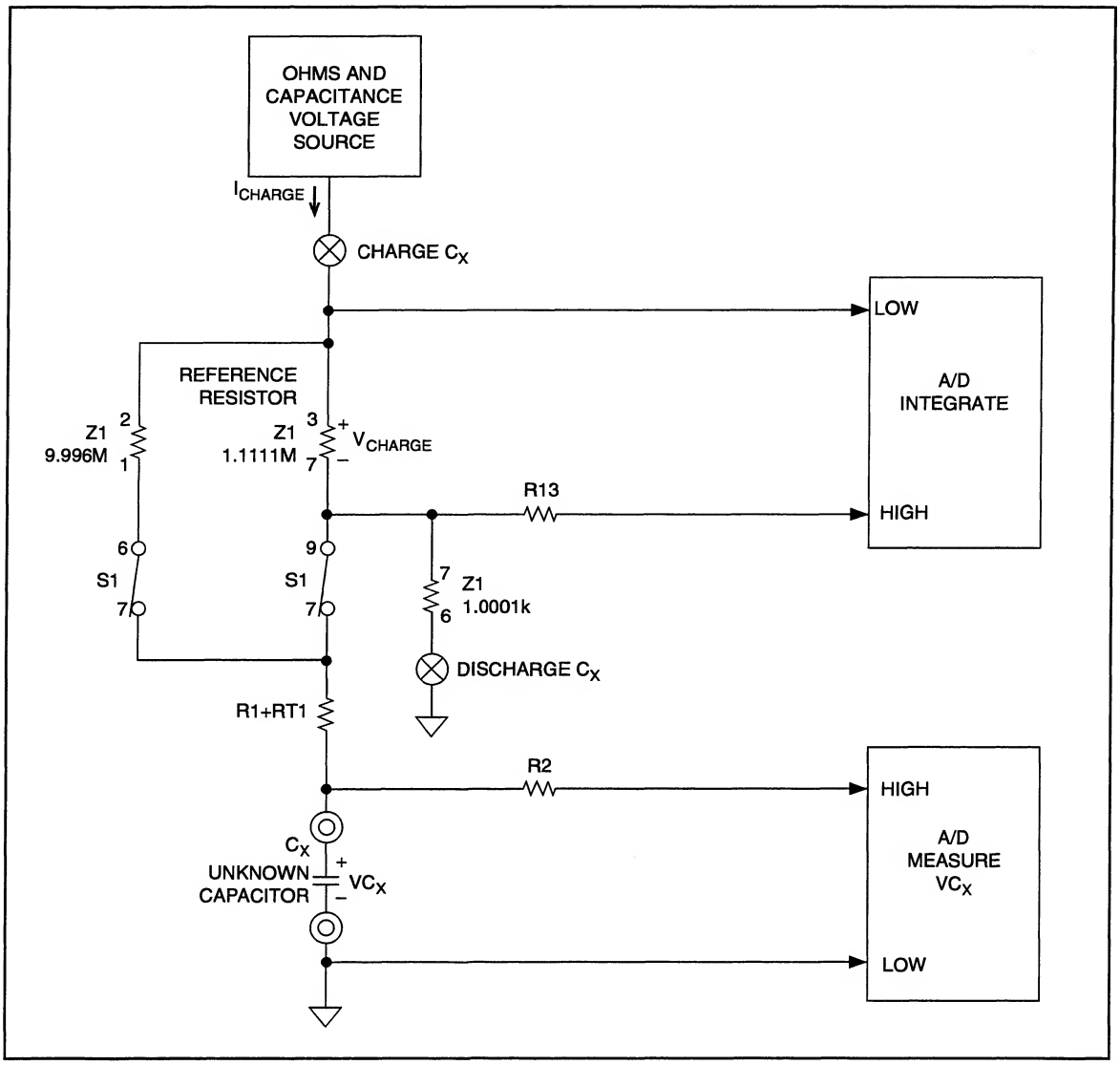


Figure 2-5. 100-nF Range Simplified Schematic

AC Converter *2-17.*

The averaging ac converter uses components R30, R31, R34, R40, C24, C28, and C29. This ac converter is a full-wave rectifying converter with a differential output, and it is gain selected to give a dc output equal to the rms value for a sine wave input. Filtering is provided by C28 and C29.

Active Filter *2-18.*

The active filter uses components R17, R18, C8, and C9. The active filter is a second order low-pass filter with two poles at 5.9 Hz in normal mode. It filters input signal noise and ac ripple from the ac converter, yielding stable a/d converter readings. The microcomputer can disable the filter completely or enable the filter fast response mode by shorting R17 and R18 with internal IC switches.

A/D Converter 2-19.

Precision resistor network Z1-8, 9, and 10 connects to the three a/d buffer/integrator range resistors. Z1-8 connects to 190 kΩ for the 1-volt range (de-integrate). Z1-9 connects to 166 kΩ for the 400 mV range, and Z1-10 connects to 16 kΩ for the 40 mV range. Z1-11 is the summing node of the integrator circuit. The autozero capacitor (C10) stores op amp and comparator offsets. The integrator capacitor is C11.

The system reference voltage (1.23V) is generated by VR1 and R44. The 1.000V reference voltage for the a/d converter is supplied through U4-1 (REFI). This voltage is adjusted by R21, the dc calibration potentiometer in conjunction with R19 and R20. In addition to generating the a/d reference, the VR1 voltage is used for power supply reference, voltage comparator offset generation, and the ohms and capacitance source voltage.

Beeper 2-20.

Devices Q9, Q11, R57, R63, and R64 make up the beeper drive circuit.

Power Supply 2-21.

The power supply consists of two regulators, one shunt and one series, which set Vdd at +3.0V and Vss at -3.2V for all battery voltages down to 6.5V. The shunt (common) regulator sets |Vdgnd - Vss| (Vdgnd = COM = 0V) and consists of an op amp and current shunt devices integrated on U4. Resistors R37 and R38 provide voltage division. The series (Vdd) regulator, which sets |Vdd-Vdgnd|, is made up of another on-chip op amp, along with devices Q3, R24, and R25. Q3 is the series regulator element, and R24 and R25 are for voltage sensing. Capacitors C14 and C21 provide circuit compensation and power supply decoupling for the shunt and series regulators, respectively. Q10 provides base drive for Q3 at turn on. Voltage level information is presented in Table 2-1.

Display 2-22.

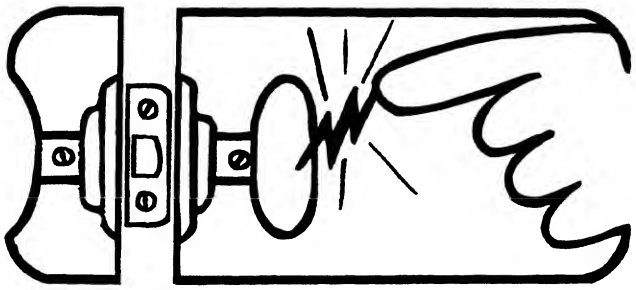
The liquid-crystal display (LCD) operates under control of the microcomputer. Segments are driven by the computer and displayed on the LCD. Both digital readings and an analog bar-graph display are presented in conjunction with annunciators and decimal points. Refer to the Fluke 79/29 User's Manual for information about the display.

Table 2-1. Typical Voltage Levels and Tolerance (Referenced to Common)

VDD	3.0 ± 0.2
VSS	-3.2 ± 0.2
VBT-	-6.1 (battery at full 9V charge)
	-3.2 (battery at low charge of 6.5V)
REFH	1.23 ± 0.04
PS0	1.23 ± 0.15
PS1	0 ± 0.15
VOA	2.2 to 1.7 (referenced from VSS)
VOB	1.07 to .85 (referenced from VSS)

static awareness

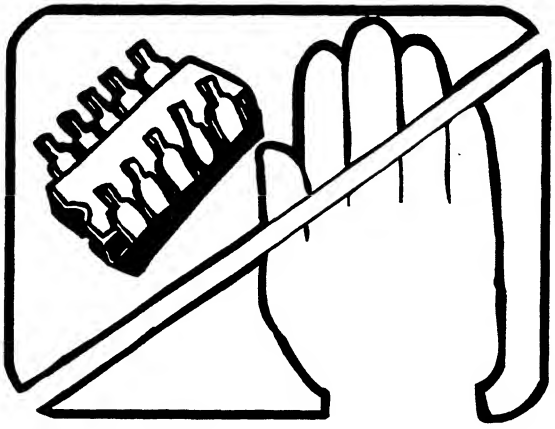
A Message From
Fluke Corporation



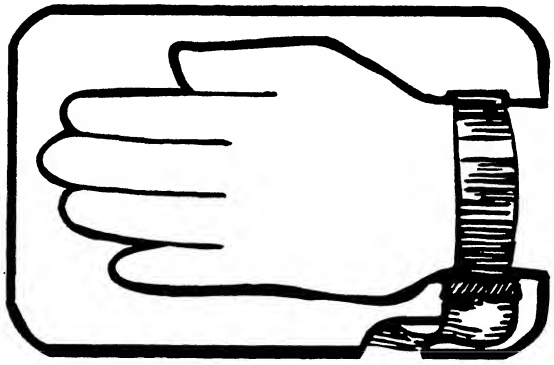
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Leaning the guidelines for handling them.
3. Using the procedures, packaging, and bench techniques that are recommended.

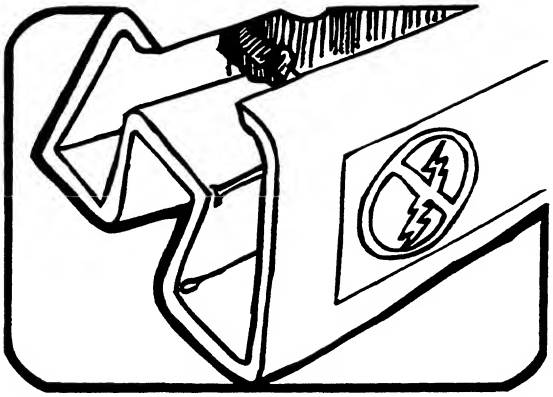
The following practices should be followed to minimize damage to S.S. (static sensitive) devices.



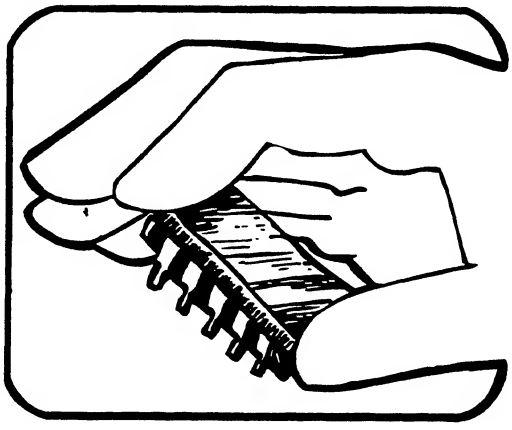
1. MINIMIZE HANDLING



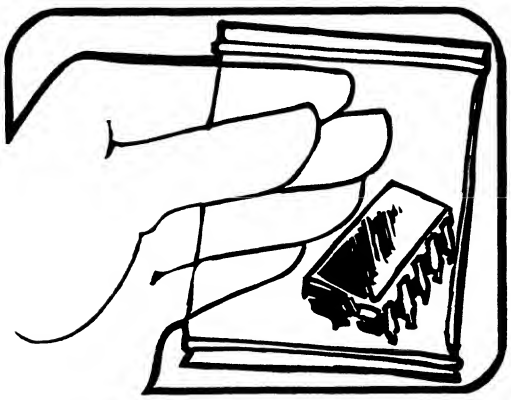
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



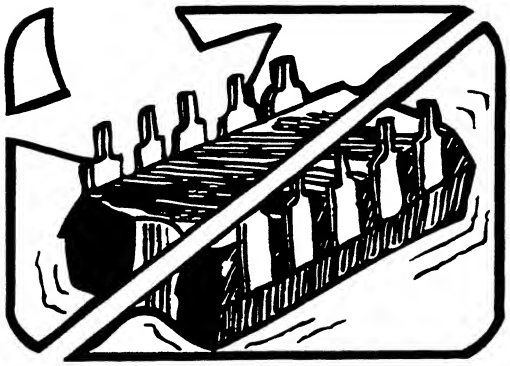
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



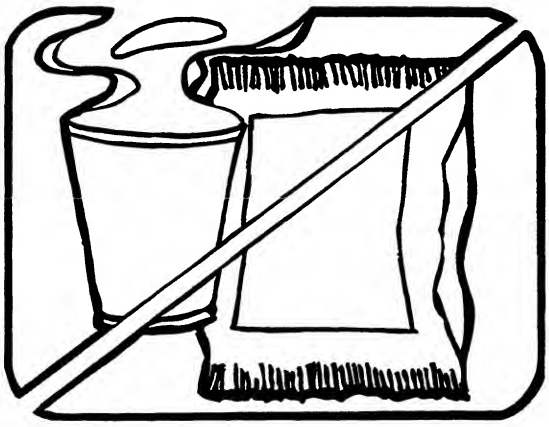
4. HANDLE S.S. DEVICES BY THE BODY.



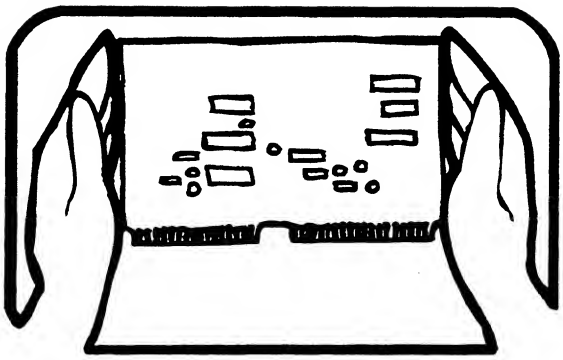
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT.



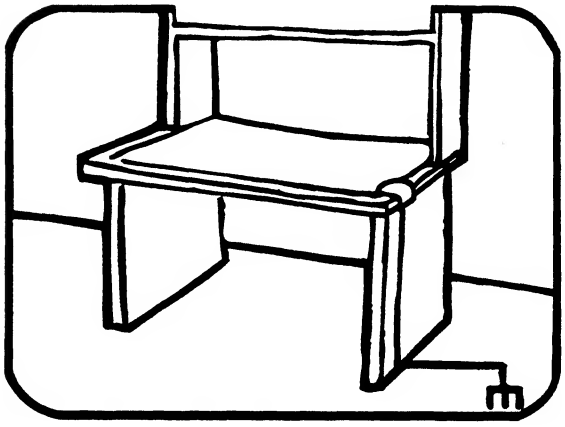
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE.



7. AVOID PLASTIC,VINYL AND STYROFOAM® IN WORK AREA.



8. WHEN REMOVING PLUG-IN ASSEMBLIES HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS PROTECT INSTALLED S.S. DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION.

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED-TIP SOLDERING IRONS SHOULD BE USED.

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Chapter 3
Maintenance

WARNING

THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE USER'S OR SERVICE MANUAL UNLESS YOU ARE QUALIFIED TO DO SO.

Introduction *3-1.*

This section contains maintenance information for the Fluke 79 and 29 meters and includes performance tests, calibration, general maintenance procedures, and troubleshooting. For operator maintenance and instrument specifications, refer to the User's Manual (P/N 896196).

The performance tests are recommended as a preventive maintenance tool to verify proper instrument operation. A one year calibration cycle is recommended to maintain the specifications given in the Users Manual.

Recommended Equipment *3-2.*

Test equipment recommended for the performance tests and calibration is listed in Table 3-1. If the recommended equipment is not available, instruments with equivalent specifications may be used.

Table 3-1. Recommended Test Equipment

EQUIPMENT	MINIMUM SPECIFICATIONS	RECOMMENDED MODEL
DMM Calibrator plus Transconductance or Power Amplifier	DC Voltage: 0-1000V Accuracy: .05% AC Voltage: 0-750V Accuracy: 0.2% Frequency: 40 Hz-20 kHz DC mA: 0-35 mA DCA: 0-10A Accuracy: 0.1% AC mA: 0-35 mA ACA: 0-10A Accuracy: 0.3% Frequency: 40 Hz-1 kHz	Fluke Models (5100B, 5101B, 5102B, 5700A) + 5220A or Fluke Models 5700A + 5725A
Function Generator	Sinewave voltage: 0-1V rms Frequency: 1 Hz-20 kHz Frequency Accuracy: .002%	Philips 5190X
Decade Resistor	Resistance 0-35 MΩ: Accuracy: .05%	General Resistance RDS-77B
Decade Capacitor	Capacitance: 100 pF-1.1 µF Accuracy: 0.5%	GenRad 1412-BC

Operator Maintenance 3-3.

WARNING

TO AVOID ELECTRICAL SHOCK, REMOVE THE TEST LEADS BEFORE OPENING THE CASE, AND CLOSE THE CASE BEFORE OPERATING THE METER. TO PREVENT FIRE, INSTALL FUSES WITH THE RATING SHOWN ON THE BACK OF THE METER.

CAUTION

To avoid contamination with oil from the fingers, handle the pca by the edges or wear gloves. PCA contamination may not cause immediate instrument failure in controlled environments. Failures typically show up when contaminated units are operated in humid areas.

Case Disassembly 3-4.

Use the following procedure to disassemble the case:

1. Set the function switch to OFF and disconnect the test leads if they are installed.
2. Remove the four Phillips screws from the bottom cover.
3. Turn the meter face up, grasp the top cover, and pull the top cover from the meter.

Battery Replacement 3-5.

The meter is powered by a single 9V battery (NEDA 1604, 6F22, or 006P). Refer to Figure 3-1, and use the following procedure to replace the battery:

1. Remove the upper case as described under Case Disassembly.
2. Lift the battery from the case bottom and install the new battery.

Fuse Test 3-6.

Use the following procedure to test the internal fuses of the meter.

1. Turn the rotary selector switch to the Ω —|(— position.
2. Plug a test lead into the VΩ→|— input terminal, and touch the probe to the 10A input terminal.
3. The display should indicate between 0.1 and 0.5 ohms. This tests F2 (15A, 600V). If the display reads OL (overload), replace the fuse and test again. If the display reads any other value, further servicing is required.
4. Move the probe from the 10A input terminal to the 40 mA input terminal.
5. The display should read between 10 ohms and 12 ohms. This procedure tests F1 (1A, 600V). If the display reads a high resistance or OL (overload), replace the fuse and test again. If the display reads any other value, further servicing is required.

Fuse Replacement 3-7.

Refer to Figure 3-1, and use the following procedure to examine or replace the meter's fuses:

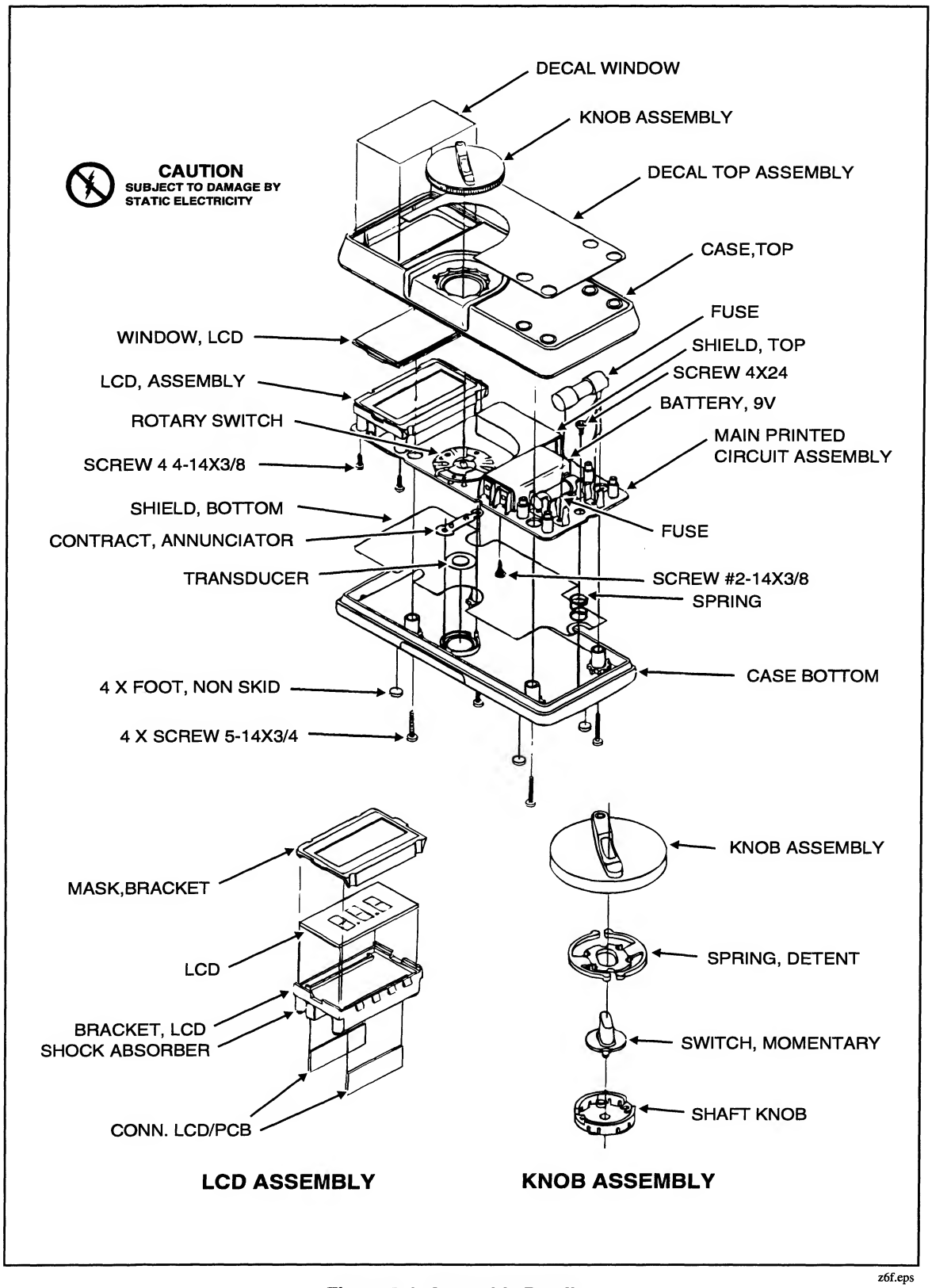

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Figure 3-1. Assembly Details

1. Remove the upper case.
2. Remove the defective fuse by gently prying one end of the fuse loose and sliding the fuse out of the fuse bracket.
3. Install a new fuse of the same size and rating. Make sure the new fuse is centered in the fuse holder.
4. Ensure that the case top rotary switch and circuit board switch are in the OFF position.
5. Reinstall the four Phillips screws into the bottom cover.

Circuit Assembly Removal 3-8.

1. The 15A fuse, F2, must be removed to access the screw that holds the pca to the case bottom (refer to Fuse Replacement, above).

NOTE

Be careful not to lose the spring located directly under the screw on the back side of the pca.

2. The pca may now be removed from the bottom cover.

Display Access 3-9.

CAUTION

To prevent contamination, do not handle the conductive edges of the LCD interconnects. If they are contaminated, clean them with alcohol.

Refer to Figure 3-1.

1. Remove the four Phillips screws from the back side of the pca.
2. Remove the LCD mounting bracket.
3. Insert a small screwdriver under the edges of the display holding bracket, and gently pry the bracket loose from the snaps.
4. Turn the bracket upside down to remove the LCD.
5. Before installing a new LCD, make sure that all connector contact points are clean.

Cleaning 3-10.

CAUTION

To avoid damaging the meter, do not use aromatic hydrocarbons or chlorinated solvents for cleaning. These solutions will react with the plastics used in the instruments.

Do not allow the LCD to get wet. Remove the display assembly before washing the pca and do not reinstall it until the pca is completely dry.

Do not use detergent of any kind for cleaning the pca.

Do not remove lubricants from the switch when cleaning the pca.

Clean the instrument case with a mild detergent and water.

The pca may be washed with isopropyl alcohol or deionized water and a soft brush. Remove the display assembly and fuses before washing, and avoid washing the switch if possible. Dry the pca with clean dry air at low pressure, then bake it at 50°C for 24 hours.

Performance Tests 3-11.

Performance tests are recommended for incoming inspection, periodic maintenance, and for verifying the specifications in the Users Manual. If the instrument fails any part of the test, calibration and/or repair is indicated.

In the performance tests, the Fluke 79 and 29 meters are referred to as the unit under test (UUT).

Setup 3-12.

1. Allow the UUT to stabilize to room temperature 23°C ± 5°C (73°F ± 9°F).
2. Check the fuses and battery, and replace them if necessary. (Refer to the battery and fuse replacement procedures in this section.)

WARNING

TO PREVENT FIRE, INSTALL FUSES IN ACCORDANCE WITH THE RATING SHOWN ON THE BACK OF THE METER.

WARNING

CONNECT THE GROUND/COMMON/LOW SIDE OF THE DC CALIBRATOR TO COMMON ON THE UUT.

Display Test 3-13.

To test the display, turn the UUT on and check whether all display segments come on as indicated in Figure 3-2.

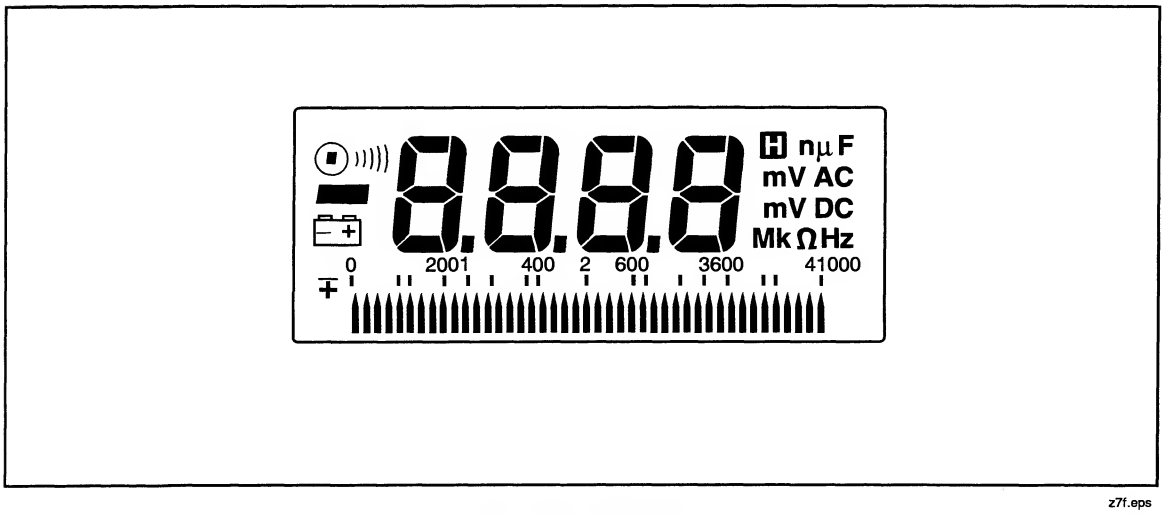

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Figure 3-2. Display

Dc Voltage Test 3-14.

1. Set the UUT function switch to V DC and connect the DC Voltage Calibrator output to the VΩ→⊣ and COM input terminals of the UUT.
2. Referring to Table 3-2, set the DC Voltage Calibrator for the output indicated in steps 1 through 6. Verify that the UUT display reading is within the limits shown.

Table 3-2. DC Voltage Test

STEP	INPUT		DISPLAY READING
	RANGE	VOLTAGE	
1	4V	short	0 to ±.001V DC
2	4V	+3.5V	3.488 to 3.512V DC
3	4V	-3.5V	-3.488 to -3.512V DC (and within 2 counts of +3.5V reading)
4	40V	+35V	34.88 to 35.12V DC
5	400V	+350V	348.8 to 351.2V DC
6	1000V	+1000V	996 to 1004V DC

3. Reset the source to 0V.

mV DC Test 3-15.

1. Set the UUT function switch to mV DC, and connect the DC Voltage Calibrator output to the VΩ→⊣ and COM input terminals of the UUT.

NOTE

For autorange, press and hold the push button for 1 second.

2. Referring to Table 3-3, set the DC Voltage Calibrator to the voltage indicated in the steps. Verify that the UUT display reading is within the limits shown.

Table 3-3. mV DC Voltage Test

STEP	INPUT		DISPLAY READING
	RANGE	VOLTAGE	
1	400 mV	+350 mV	348.8 to 351.2 mV DC
2	40 mV	SHORT	0 to ±.05 mV DC
3	40 mV	+35 mV	34.84 to 35.16 mV DC
4	40 mV	-35 mV	-34.84 to -35.16 mV DC

3. Reset the source to 0V.

AC Voltage Test 3-16.

WARNING

INJURY HAZARD. CONNECT THE GROUND/COMMON/LOW SIDE OF THE AC CALIBRATOR TO COMMON ON THE UUT.

1. Set the UUT function switch to V AC, and connect the AC Calibrator to the VΩ→⊣ and COM input terminals.
2. Set the AC Calibrator for the output given in Table 3-4, and verify that the UUT display reading is within the limits shown.

Table 3-4. AC Voltage Test

STEP	INPUT			DISPLAY READING
	RANGE	VOLTAGE	FREQ.	
1	400 mV	short	----	0 to 0.4 mV AC
2	400 mV	350 mV	100 Hz	342.9 to 357.1 mV AC
3	400 mV	350 mV	1 kHz	342.9 to 357.1 mV AC
4	4V	3.5V	100 Hz	3.431 to 3.569V AC
5	4V	3.5V	1 kHz	3.431 to 3.569V AC
6	40V	35V	1 kHz	34.63 to 35.37V AC
7	400V	350V	1 kHz	346.3 to 353.7V AC
8	750V	750V	1 kHz	740 to 760V AC

NOTE

When the input is open in the V AC function, it is normal for the meters to read some counts on the display. This is due to ac pickup in the ac amplifier when the ac amplifier is unterminated.

Frequency Test 3-17.

1. Set the UUT function switch to Hz and connect the Function Generator output to the VΩ→⊣ and COM input terminals of the UUT.
2. Referring to Table 3-5, set the Function Generator for the output indicated in the steps. Verify that the UUT display reading is within the limits shown.

Table 3-5. Frequency Test

STEP	INPUT			DISPLAY READING
	RANGE	VOLTAGE	FREQ.	
1	4V	300 mV	800 Hz	799.8 Hz to 800.2 Hz
2	4V	300 mV	20 kHz	19.99 kHz to 20.01 kHz

Ohms Test 3-18.

1. Select the ohms function on the UUT.
2. Connect the Ohms Calibrator or Decade Resistor to the VΩ→⊢ and COM input terminals of the UUT.
3. Referring to Table 3-6, set the Decade Resistor or Ohms Calibrator to the resistance value indicated in steps 1 through 7. Verify that the display reading is within the limits shown.

Table 3-6. Resistance Test

STEP	RANGE	INPUT RESISTANCE	DISPLAY READING
1	400Ω	short	0 to 0.2Ω
Decades of 1:			
2	400Ω	100Ω	99.4 to 100.6Ω (plus 0 reading)
3	4 kΩ	1 kΩ	.995 to 1.005 kΩ
4	40 kΩ	10 kΩ	9.95 to 10.05 kΩ
5	400 kΩ	100 kΩ	99.5 to 100.5 kΩ
6	4 MΩ	1 MΩ	.995 to 1.005 MΩ
7	40 MΩ	10 MΩ	9.87 to 10.13 MΩ
Decades of 1.9:			
2	400Ω	190Ω	189.0 to 191.0Ω (plus 0 reading)
3	4 kΩ	1.9 kΩ	1.891 to 1.909 kΩ
4	40 kΩ	19 kΩ	18.91 to 19.09 kΩ
5	400 kΩ	190 kΩ	189.1 to 190.9 kΩ
6	4 MΩ	1.9 MΩ	1.891 to 1.909 MΩ
7	40 MΩ	19 MΩ	18.78 to 19.22 MΩ
Decades of 3.5:			
2	400Ω	350Ω	348.4 to 351.6Ω (plus 0 reading)
3	4 kΩ	3.5 kΩ	3.485 to 3.515 kΩ
4	40 kΩ	35 kΩ	34.85 to 35.15 kΩ
5	400 kΩ	350 kΩ	348.5 to 351.5 kΩ
6	4 MΩ	3.5 MΩ	3.485 to 3.515 MΩ
7	40 MΩ	35 MΩ	34.62 to 35.38 MΩ

Capacitance Test 3-19.

1. Set the UUT function switch to Ω —|(— and connect the Decade Capacitor output to the VΩ→|+ and COM input terminals of the UUT.

NOTE

To enter capacitance, press and hold the push button for 2 seconds.

2. Referring to Table 3-7, set the Decade Capacitor for the output indicated in the steps. Verify that the UUT display reading is within the limits shown.

Table 3-7. Capacitance Test

STEP	INPUT		
	RANGE	CAPACITANCE	DISPLAY READING
1	100 nF	open, no test leads	0 to 0.50 nF
2	1000 nF	open, no test leads	0 to 0.5 nF
3	1000 nF	800 nF	784.6 to 815.4 nF
4	10 µF	1.1 µF	1.077 to 1.123 µF

Continuity Test 3-20.

1. Set the UUT function switch to 40 Ω ( )))).

2. Referring to Table 3-8, apply a short as indicated. Verify that the UUT display and beeper indicate as shown.

Table 3-8. Continuity Test

STEP	RANGE	INPUT	DISPLAY READING
1	400Ω	short	tone
2	400Ω	open	OL

Diode Test 3-21.

1. Set the UUT function switch to 40 Ω))) —|(— and enter diode test by holding the push button for 2 seconds.

2. Verify that the display shows OL when the test leads are open and that the meter emits a tone when the test leads are shorted together.

DC and AC Current Test 3-22.

1. Set the output of the Current Calibrator to standby and connect it to the 40 mA and input terminals of the UUT.

2. Set the Current Calibrator to the output shown in Table 3-9, and verify that the UUT display reading is within the limits shown.

Table 3-9. DC and AC mA Test

STEP	INPUT			DISPLAY READING
	RANGE	A	FREQ	
1	40 mA dc	+35 mA		34.80 to 35.20 DC
NOTE To enter AC mA, press and hold the button for 2 seconds.				
2	40 mA ac	35 mA	1 kHz	34.45 to 35.55 mA AC

3. Set the output of the Current Calibrator to standby and connect it to the 10A and Common input terminals of the UUT.
4. Return the UUT to A DC.
5. Set the Current Calibrator to the output shown in Table 3-10, and verify that the UUT display reading is within the limits shown.

Table 3-10. DC Amps Test

STEP	INPUT		DISPLAY READING
	RANGE	A	
2	10A dc	+10A	9.93 to 10.07 DC

Calibration *3-23.*

Calibrate the meter once a year to ensure that it performs according to specifications. Calibration adjustment points are identified in Figure 3-3.

Use the following procedure to calibrate the Fluke 79/29.

1. Set the DC Voltage Calibrator to 0 volts.
2. Select the $\overline{\overline{V}}$ function on the meter.
3. Connect the DC Voltage Calibrator to the VΩ⊣◂ and COM input terminals of the UUT.
4. Set the DC Voltage Calibrator for an output of +3.5V dc.
5. The UUT should display 3.500V dc ± 0.001. If necessary, remove the four case screws and top cover, and adjust R21 to obtain the proper display.
6. Set the UUT to the V~ function, and set the source for an output of 3.500V ac at 100Hz.
7. The UUT should display 3.500V ac ± 0.002. If necessary, remove the four case screws and top cover and adjust R34 to obtain the proper display.

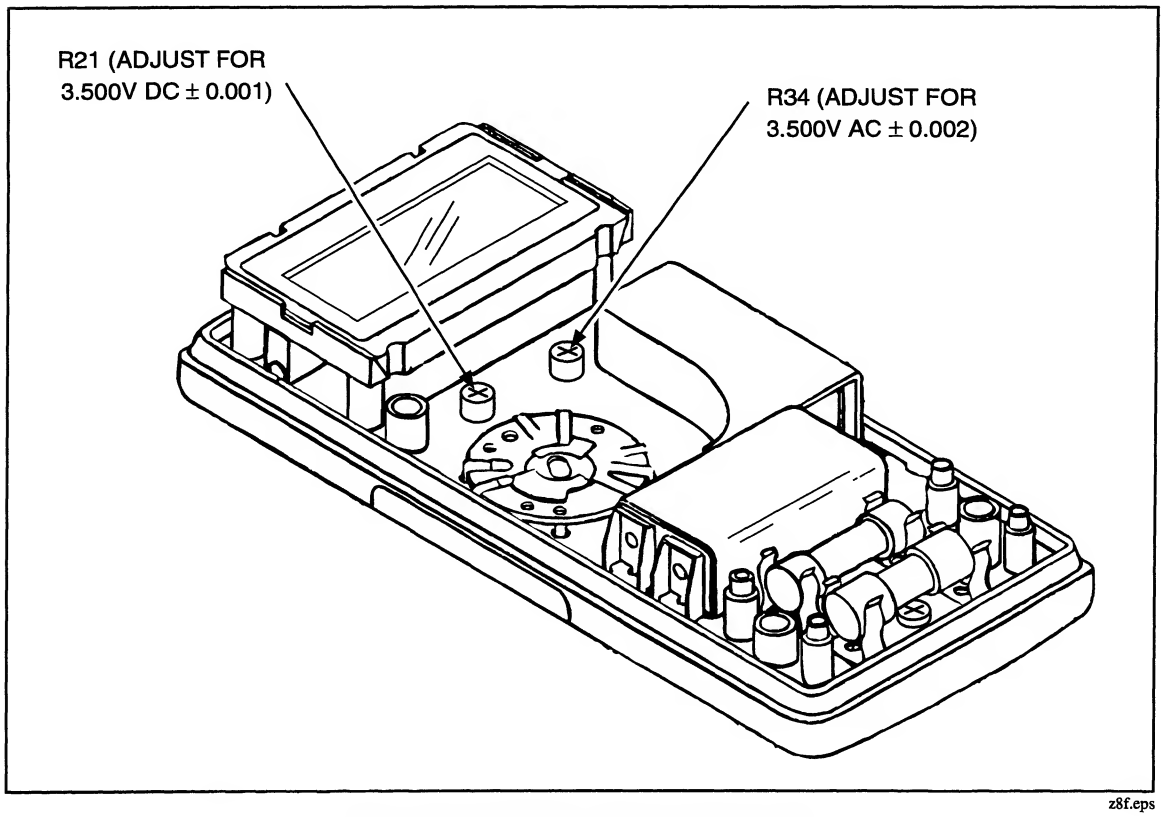

Figure 3-3. Calibration Adjustment Points

Troubleshooting 3-24.

The procedures provided in these paragraphs will help isolate problems with the meter. In these procedures, the meters are referred to as the unit under test (UUT).

When troubleshooting the Fluke 79 and 29 meters, use the precautions listed on the "Static Awareness Sheet" to prevent damage from static discharge.

Surface Mount Assemblies 3-25.

The 79 and 29 multimeters incorporate surface-mount technology (SMT) on the printed circuit assembly (pca). Surface-mount components are much smaller than their predecessors, with leads soldered directly to the surface of a circuit board; no plated through-holes are used. Unique servicing, troubleshooting, and repair techniques are required to support this technology. The information offered in the following paragraphs serves only as an introduction to SMT. We do not recommend that you attempt a repair based only on the information presented here.

Since sockets are seldom used with SMT, "shotgun" troubleshooting cannot be used; isolate a fault to the component level before replacing a part. Surface-mount assemblies are probed from the component side. The probes should contact only the pads in front of the component leads. With the close spacing involved, ordinary test probes can easily short two adjacent pins on an SMT IC.

Due to the limited space on the surface of the circuit board, component locations are not labeled. Therefore, this service manual is a vital source for component locations and values. Figures provided in Chapter 5 of this manual provide component location information. Also, remember that chip components are not individually labeled; keep any new or removed component in a labeled package.

Surface-mount components are removed and replaced by reflowing all the solder connections at the same time. Special considerations are required.

- The solder tool uses regulated hot air to melt the solder; there is no direct contact between the tool and the component.
- Surface-mount assemblies require rework with wire solder rather than with solder paste. A 0.025 inch diameter wire solder composed of 63% tin and 37% lead is recommended. A 60/40 solder is also acceptable.
- A good connection with SMT requires only enough solder to make a positive metallic contact. Too much solder causes bridging, while too little solder can cause weak or open solder joints. With SMT, the anchoring effect of the through-holes is missing; solder provides the only means of mechanical fastening. Therefore, the pca must be especially clean to ensure a strong connection. An oxidized pca pad causes the solder to wick up the component lead, leaving little solder on the pad itself.

Refer to the Fluke "Surface Mount Device Soldering Kit" for a list of special tools required to perform circuit assembly repair. (In the USA, call 1-800-526-4731 to order).

Power Supply Related Troubleshooting *3-26.*

The two regulator circuits are interrelated; a malfunction in either the common regulator or the Vdd regulator may cause a problem in the other. Refer to Tables 3-11 and 3-12 for descriptions of power supply components and voltage levels. To isolate the problem regulator circuit, disconnect the battery, and drive Vdd - Vss = 6.2V with a power supply. This procedure tests the common regulator independently of the Vdd regulator.

Table 3-11. Functional Description of Power Supply Components

COMPONENT	FUNCTION
Q10	Power supply startup device. Q10 provides Q8 base startupcurrent. Q10 is always off during meter operation.
VR1	VR1 provides the system reference voltage. It is used for the a/d converter reference and as a reference for both power supply regulators.
C14	Vdd regulator compensation and bypass.
C21	Common regulator compensation and Vss bypass.
C35	Battery bypass.
R24, R25	Vdd regulator voltage sensing resistors.
R37, R38	Common regulator voltage sensing resistors.
R44	Supplies bias current to VR1.

Table 3-12. Voltage Levels

VDD	3.0 ± 0.2
VSS	3.2 ± 0.2
VBT-	6.1 (battery at full 9V charge)
	3.2 (battery at low charge of 6.0V)
REFH	1.23 ± 0.04
PS0	1.23 ± 0.15
PS1	0 ± 0.15
VOA	2.2 to 1.7 (referenced from VSS)
VOB	1.07 to .85 (referenced from VSS)

Now check for Vdgnd - Vss = -3.2V ±0.2V. If this test is successful, the problem lies with the Vdd regulator; refer to Vdd Regulator Troubleshooting later in this section. If this test is not successful, the problem lies with the common regulator; continue with the Common Regulator Troubleshooting below.

Note that if the common regulator works or has been repaired, check both supplies with the 9V battery supply.

Common (Shunt) Regulator Troubleshooting *3-27.*

To troubleshoot the common regulator, connect the power supply so that Vdd, Vss, and DGND (digital ground) are supplied from an external power supply. This procedure overdrives the large on-chip shunt transistors; the bias current from the power supply ranges from 10 mA to 100 mA. Refer to the schematic for a diagram of the common regulator. Make the following tests:

1. Check for +1.23V ±40 mV (Vrefh) at the cathode of VR1. If Vrefh is not correct, check VR1, R19, R20, R21 and R44 carefully. If Vrefh is still incorrect, U4 is bad.
2. If Vrefh is correct, measure the voltage at U4 pin 6 (PS1). If Vps1 is not equal to 0V ±0.15V, check R37 and R38. If Vps1 is still at an incorrect voltage, U4 is bad.
3. Check the bias generator circuit. With the exception of resistor R35 (620 kΩ), the bias generator (which sets the bias level for all U4 analog circuitry) is internal to U4. A problem with this circuit could cause the on-chip power supply op amps to fail. Measure the dc voltage between U4 pin 8 (Vbias) and DGND. If -0.2V < Vbias < + 0.2V the bias generator is okay. If Vbias is not correct, check R35. If Vbias is still wrong, replace U4.
4. Measure the ac voltage between Vdgnd and Vss. If it is greater than 10 mV ac, check C21. (An open C21 causes common regulator instability.) The dc level may also be incorrect.
5. If the common regulator still does not work, circuitry internal to U4 is bad. Replace U4.

Vdd (Series) Regulator Troubleshooting 3-28.

If a problem still exists after the common regulator troubleshooting, continue with the following Vdd regulator troubleshooting. Often, a short or sneak current path causes power supply problems. Refer to the schematic for a diagram of the Vdd (Series) Regulator. Make the following tests:

1. Measure the dc operating current from the 9V battery. If the current is greater than 1.2 mA, a sneak current path exists. A sneak current path can be very difficult to find.
2. First, visually check for both solder bridges on U4 pins and other circuit board shorts.

Isolate the current path at the negative battery terminal (Vbt-). The components connected to Vbt- are C35, CR4, and R63. Remove these parts one at a time. Measure I(bat) after each removal to isolate the problem.

1. If the excess battery current stops after removing R63, either R63, R57, Q9, or Q11 may be bad.
2. If the extra current is still present with all parts removed, remove Q10 and check for excess battery current. If I(bat) is now correct, Q10 is bad. If I(bat) is still excessive, U4 is probably at fault.

If the power supply is not working but battery current is normal, perform the following tests.

1. If Vdd - Vss is low, a problem may exist with start-up device Q10. Check Q10 by momentarily connecting Vss to Vbt-. If both Vss and Vbt- now start up and operate correctly, check Q10 for an open.
2. Measure the ac voltage between Vdd and Vss. An unstable Vdd regulator can be caused by an open C14. If the voltage is greater than 10-mV ac, check C14. The dc level may also be incorrect.

For a final check of U4, remove the battery and supply Vdd = +3.0V, Vdgnd = 0, and Vss = -3.2V from an external power supply. Measure the voltage at U4 pin 7 (Vps0). If it does not equal 1.23V ± 0.15V, check R24 and R25 carefully. If Vps0 is still incorrect, U4 is bad.

Chapter 4
List of Replaceable Parts

Introduction 4-1.

This chapter contains an illustrated list of replaceable parts for the Fluke 79 and Fluke 29 Multimeters. Parts are listed by assembly; alphabetized by reference designator. Each assembly is accompanied by an illustration showing the location of each part and its reference designator. The parts lists give the following information:

- Reference designator
- An indication if the part is subject to damage by static discharge
- Description
- Fluke stock number
- Total quantity
- Any special notes (i.e., factory-selected part)

Caution

A * symbol indicates a device that may be damaged by static discharge.

How to Obtain Parts 4-2.

Electrical components may be ordered directly from the Fluke Corporation and its authorized representatives by using the part number under the heading FLUKE STOCK NO. In the U.S., order directly from the Fluke Parts Dept. by calling 1-800-526-4731. Parts price information is available from the Fluke Corporation or its representatives. Prices are also available from the Fluke Corporation or its representatives.

In the event that the part ordered have been replace by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

To ensure prompt delivery of the correct part, include the following information when you place an order:

- Instrument model and serial number
- Part number and revision level of the pca containing the part
- Reference designator
- Fluke stock number
- Description (as given under the DESCRIPTION heading)
- Quantity

Manual Status Information 4-3.

The Manual Status Information table that precedes the parts list, defines the assembly revision levels that are documented in the manual. Revision levels are printed on the component side of each pca.

Newer Instruments 4-4.

Changes and improvements made to the instrument are identified by incrementing the revision letter marked on the affected pca. These changes are documented in a manual supplement which, when applicable, is included with the manual.

Service Centers 4-5.

A list of service centers is located at the end of this chapter.

Note Ni-Cd

This instrument may contain a Nickel-Cadmium battery. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke service center for recycling information.

WARNING

THIS INSTRUMENT CONTAINS A FUSIBLE RESISTOR (PN 832550). TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.

Manual Status Information

REF OR OPTION NO.	ASSEMBLY NAME	FLUKE PART NO.	REVISION LEVEL
A1	Main PCA	930458	H

Table 4-1. Final Assembly (Models 79,29)

Reference Designator		Description	Fluke Stock No	Tot Qty	Notes
A1	*	MAIN PCA	NON-PROCURABLE		
BT1		BATTERY,9V,0-15MA	696534	1	
F1		FUSE,.406X1.375,1A,600V,FAST	830828	1	
F2		FUSE,.406X1.5, 15A, 600V, FAST	820829	1	
H1		SCREW,PH,P,THD FORM,STL,4-24,.250	519116	1	
H2		SCREW,PH,P,THD FORM,STL,2-14,.375	821140	1	
H3		SCREW,PH,P,AM THD FORM,STL,4-14,.375	448456	4	
H7		SCREW,PH,P,AM THD FORM,STL,5-14,.750	733410	4	
LS1		AF TRANSD,PIEZO,20 MM	642991	1	
MP9		SHIELD,TOP	885855	1	
MP10		FOOT,NON-SKID	640565	4	
MP14		CASE,BOTTOM	900712	1	1
MP15		SHIELD,BOTTOM	896225	1	
MP16		SPRING,COIL,COMP,M WIRE,.500,.360	697227	1	
MP17		CASE,TOP	885868	1	2
MP18		WINDOW,LCD	896167	1	3
MP19		BRACKET,LCD	646653	1	
MP20		MASK/BRACKET, GRAY #6	885848	1	
MP21		CONN,ELASTOMERIC,LCD TO PWB,1.900 L	649632	2	
MP23		KNOB,SWITCH	885843	1	4
MP24		SHAFT,KNOB	646661	1	
MP25		SPRING,DETENT	646679	1	
MP26		SHOCK ABSORBER	428441	1	
MP27		DECAL,TOP CASE	890285	1	5
MP28		LABEL,WINDOW	844340	1	
MP31		HOLSTER & FLEXSTAND ASSY, YELLOW	890298	1	
MP32		TEST LEADS	855742	1	
MP33		GUIDE,SADDLE ST,DMM ACCESSORY LIST	825851	1	
MP34		CARD,QUICK REF,FLUKE 79/29	897801	1	
MP54		SHOCK ABSORBER	900837	1	
S2		SWITCH,MOMENTARY, YELLOW	890280	1	6
S4		CONTACT,ANNUNCIATOR	642983	1	
TM1		79/29 SERIES II USERS MANUAL	896196	1	
TM2		79/29 WARRANTY & INFORMATION CARD	897806	1	
U5		LCD,4.5 DIGIT,BAR GRAPH,MULTIPLEXED	875534	1	

1. For Fluke Model 29 Order Fluke PN 896170.
2. For Fluke Model 29 Order Fluke PN 895818.
3. For Fluke Model 29 Order Fluke PN 896126.
4. For Fluke Model 29 Order Fluke PN 896129.
5. For Fluke Model 29 Order Fluke PN 895842.
6. For Fluke Model 29 Order Fluke PN 895800..

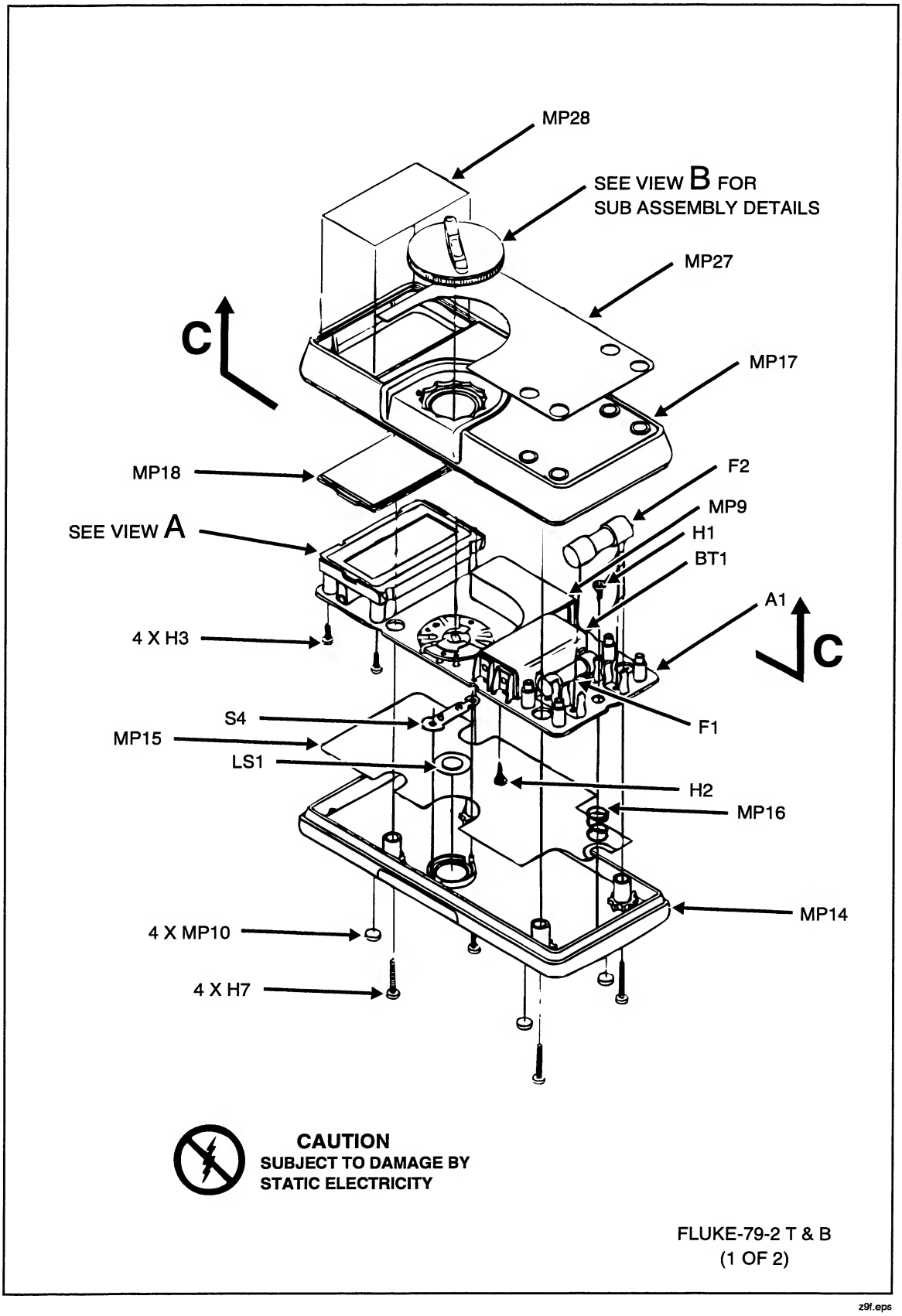

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Figure 4-1. Final Assembly (Models 79,29)

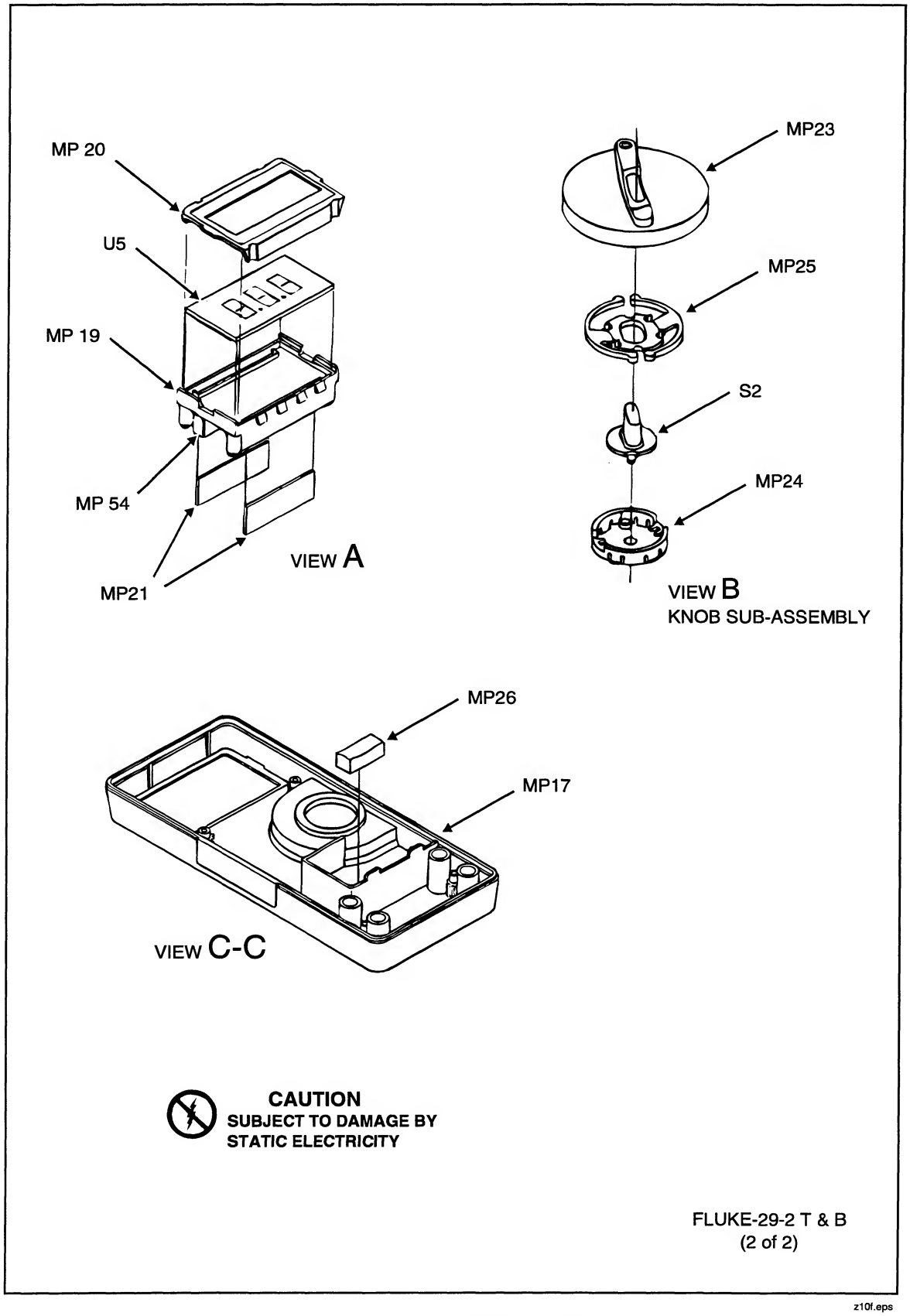

Figure 4-1. Final Assembly (Models 79,29) (cont)

Table 4-2. A1 Main PCA (Models 79,29)

Reference Designator		Description	Fluke Stock No	Tot Qty	Notes
C1		CAP,POLYES,0.01UF,+-10%,1000V	822361	1	
C5		CAP,TA,15UF,+-20%,6.3V	807636	1	
C8,C9		CAP,POLYCA,0.027UF,+-10%,63V	720979	2	
C10,C28,C29		CAP,TA,0.47UF,+-20%,25V,3216	876180	3	
C11		CAP,POLYPR,0.022UF,+-10%,63V	821579	1	
C14,C21		CAP,TA,47UF,+-20%,10V,7343	867580	2	
C15,C16		CAP,CER,0.1UF,+-10%,25V,X7R,1206	747287	2	
C17,C18		CAP,CER,22PF,+-10%,50V,C0G,1206	740563	2	
C20		CAP,CER,3.3PF,+-0.25PF,1500V,C0J	904636	1	
C24		CAP,TA,10UF,+-20%,10V	714766	1	
C26		CAP,CER,150PF,+-5%,50V,C0G,0805	866533	1	
C30		CAP,CER,220PF,+-10%,50V,C0G,1206	758078	1	
C31,C33,C34		CAP,CER,0.01UF,+-10%,50V,X7R,1206	747261	3	
C35		CAP,TA,4.7UF,+-20%,10V,3528	867262	1	
CR1,CR4		DIODE,SI,100 PIV,1 AMP,SURFACE MOUNT	912451	2	
E1		SURGE PROTECTOR,1500V,+-20%	655134	1	
J1-4		RECEPTACLE,INPUT	642959	4	
MP1,MP2		CONTACT,600V,FUSE	659524	2	
MP3,MP4		600 VOLT FUSE CONTACT	707190	2	
MP6		CONTACT,BATTERY	642967	1	
MP7		CONTACT,BATTERY	654228	1	
Q1,Q2	*	TRANSISTOR,SI,NPN,SELECT IEBO,SOT-23	821637	2	
Q3,Q9,Q12	*	TRANSISTOR,SI,NPN,SMALL SIGNAL,SOT-23	742676	3	
Q4	*	TRANSISTOR,SI,NPN,SMALL SIGNAL,SOT-23	912469	1	
Q10		TRANSISTOR,SI,P-CHAN,SOT-23	832477	1	
Q5	*	TRANSISTOR,SI,PNP,50V,0.2W,SOT-23	820910	1	
Q11	*	TRANSISTOR,SI,PNP,SMALL SIGNAL,SOT-23	742684	1	
Q13		TRANSISTOR,SI,PNP,SELECT ICER,SOT-23	887179	1	
R1		RES,MF,1K,+-1%,100PPM,FLMPRF,FUSIBLE	832550	1	1
R2	*	RES,CERM,1M,+-1%,2W,100PPM	876177	1	
R3		RES,CERM,1.5K,+-1%,.125W,100PPM,1206	810630	1	
R4,R17,R18,		RES,CERM,1M,+-1%,.125W,100PPM,1206	836387	4	
R23			836387		
R5		RES,WW,9.99,+-0.25%,1W,50PPM	876321	1	
R6		RES,WW,0.010,+-0.25%,1W,100PPM	877076	1	
R7		RES,CERM,1K,+-5%,.125W,200PPM,1206	745992	1	
R9,R13,R29,		RES,CERM,100K,+-5%,.125W,200PPM,1206	740548	6	
R60,R61,R64			740548		
R14		RES,MF,10K,+-0.1%,0.125W,100PPM	658955	1	
R15		RES,MF,90K,+-0.1%,0.125W,100PPM	658906	1	
R19		RES,CERM,56.2K,+-1%,.125W,100PPM,1206	831305	1	
R20,R25,R37		RES,CERM,205K,+-1%,.125W,100PPM,1206	769836	3	
R21		RES,VAR,CERM,100K,+-25%	912493	1	

Table 4-2. A1 Main PCA (Models 79,29) (cont)

Reference Designator		Description	Fluke Stock No	Tot Qty	Notes
R22,R38		RES,CERM,536K,+-1%,.125W,100PPM,1206	845420	2	
R24		RES,CERM,280K,+-1%,.125W,100PPM,1206	886833	1	
R28		RES,CERM,68.1K,+-1%,.125W,100PPM,1206			
R30		RES,MF,20K,+-0.25%,0.125W,50PPM	715029	1	
R31,R40		RES,CER,22.6K,+-0.5%,125W,100PPM,1206	876219	2	
R33		RES,CERM,10K,+-5%,.125W,200PPM,1206	746610	1	
R34		RES,VAR,CERM,1K,+-25%	912498	1	
R35		RES,CERM,620K,+-5%,.125W,200PPM,1206	811919	1	
R44		RES,CERM,82K,+-5%,.125W,200PPM,1206	811794	1	
R57		RES,CERM,33K,+-5%,.125W,200PPM,1206	746669	1	
R59		RES,CERM,510,+-5%,.125W,200PPM,1206	746388	1	
R62		RES,CERM,107K,+-1%,.125W,100PPM,1206	875224	1	2
R63		RES,CERM,2.2K,+-5%,.125W,200PPM,1206	746479	1	
RT1		THERMISTOR,RECT.,POS.,1K,+-40%,25C	446849	1	
RT1		THERMISTOR,RECT.,POS.,1K,+-40%,25C	446849	1	
RV1,RV2		VARISTOR,910,+-10%,1.0MA	876193	2	
S1		SWITCH,ROTARY	885876	1	
U1		DIODE,RECT,BRIDGE,BV=50V,IO=1A	912456	1	
U4	*	IC N-WELL CLASSIC, ASSEMBLY TESTED	884556	1	
VR1	*	IC, 1.23V,150 PPM T.C.,BANDGAP V. REF	634451	1	
Y1		CRYSTAL,131.072KHZ,30PPM,SURFACE MT	912464	1	
Z1		RNET,CERM,SIP,FLUKE 83 HI V DIVIDER	828152	1	

1. R1 IS A FUSIBLE RESISTOR. TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.
2. ON EARLY MODELS, R62 MAY = 110K.

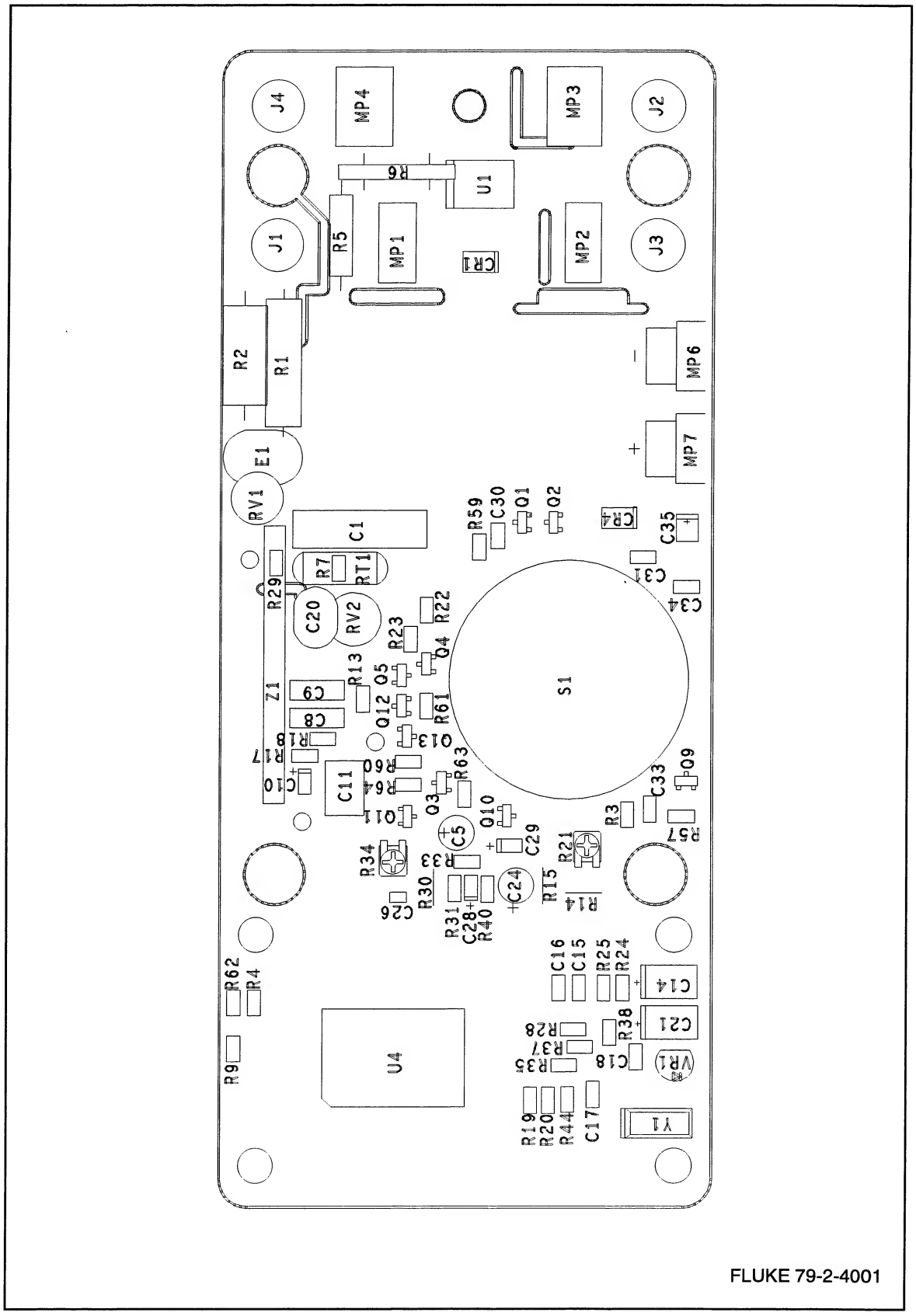

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Figure 4-2. A1 Main PCA (Models 79,29)

Service Centers

USA

California
FLW
Fluke Calibration Center
C/o FLW Service Corporation
3505 Cadillac Ave., Bldg E
Costa Mesa, CA 92626
TEL: (714) 863-9031
FAX: (714) 751-0213

Fluke Service Center
46610 Landing Parkway
Fremont, CA 94538
TEL: (510) 651-5112
FAX: (510) 651-4962

Illinois
Fluke Service Center
1150 W. Euclid Avenue
Palatine, IL 60067
TEL: (708) 705-0500
FAX: (708) 705-9989

New Jersey
Fluke Service Center
W. 75 Century Rd
Paramus, N.J. 07652-0930
TEL: (201) 599-9500 (599-0919)
FAX: (201) 599-2093

Texas
Fluke Service Center - Dallas
2104 Hutton Drive
Suite 112
Carrollton, TX 75006
TEL: (214) 406-1000
FAX: (214) 406-1072

Washington
Fluke Service Center
Fluke Corporation
Building #4
1420 - 75TH St. S.W.
Everett WA 98203
TEL: (206) 356-5560
FAX: (206) 356-6390

INTERNATIONAL

Argentina
Coasin S.A.
Virrey del Pino 4071
1430 CAP FED
Buenos Aires
TEL: 552-3485, 3185, 5248
FAX: 55-1-555-3321

Viditec S.A
Lacarra 234
Buenos Aires CP 1407
TEL: 54-1-636-1200
FAX: 54-1-636-2185

Australia
Phillips Sci. and Ind., Pty., L.
745 Springvale Road
Mulgrave
Victoria 3170
TEL: 61-3-881-3666
FAX: 61-3-881-3636

Phil. Sci. & Ind. Blk F, Centrecrt.
34 Waterloo Road
North Ryde, N.S.W. 2113
TEL: 61-2-888-8222
FAX: 61-2-888-0440

Austria
Fluke Vertriebsges. GMBH (GM)
SudrandstraBe 7
P.O. Box 10, A-1232 Vienna
TEL: 43-1-614-100
FAX: 43-1-614-1010

Bahrain
Mohammed Fakhroo & Bros.
P.O. Box 439
Bahrain
TEL: 973-253529
FAX: 973-275996

Belgium
N.V. Fluke Belgium S.A.
Sales & Service Dept.
Langeveldpark - Unit 5 & 7
P.Basteleusstraat 2-4-6
1600 St. Pieters - Leeuw
TEL: 218-2-331-2777 (ext 218)
FAX: 32-2-331-1489

Bolivia
Casilla 7295,
Calle Ayacucho No. 208
Edificio Flores, 5to. Piso
La Paz, Bolivia
TEL: 591-2-317531 or 317173
FAX: 591-2-317545

Brazil
Philips Medical Systems, LTDA
Av. Interlagos North
3493 - Campo Grande
04661-200 Sao Paulo S.P.
TEL: 55-11-523-4811
FAX: 55-11-524-4873 (ID 2148)

Sigtron Instrumentos E. Servicos
Rua Alvaro Rodriques
269 - Brooklin
Sao Paulo, Sp
TEL: 55-11-240-7359
FAX: 55-11-533-3749

Sistest
Sist. Instr. Testes Ltda
Av. Ataulfo De Paiva
135 S/ 1117 - Leblon 22.449-900
Rio De Janeiro, Rj, Brazil
TEL: 55-21-259-5755 or 512-3679
FAX: 55-21-259-5743

Bulgaria
Ac Sophilco, Cust. Supp. Serv.
P.O. Box 42
1309 Sofia, Bulgaria
TEL: 359-2-200785
FAX: 359-2-220910

C.S.F.R.
Elso
NA. Berance 2
16200 Praque 6
TEL: 42-2-316-4810
FAX: 42-2-364986

Data Elektronik BRNO
Jugoslavska 113
61300 Bmo
TEL: 42-5-57400-2
FAX: 42-5-574002

Canada
Fluke Electronics Canada Inc.
400 Britannia Rd East, Ut #1
Mississauga, Ontario
L4Z 1X9
TEL: 905-890-7600
FAX: 905-890-6866

Chile
Intronica, Instrumen Electronica, S.A.C.I.
Guardia Vieja 181 Of. 503
Casilla 16500, Santiago 9
TEL: 56-2-232-3888
FAX: 56-2-231-6700

China
Fluke S.C., Room 2111
Scite Tower
Jianguomenwai Dajie
Beijing 100004, PRC
TEL: 86-10-512-6351,6319, 3437
FAX: 86-10-512-3437

Colombia
Sistemas E Instrument., Ltda.
Calle 83, No. 37-07
Po Box 29583
Santa Fe De Bogota
TEL: 57-1-287-5424
FAX: 57-1-218-2660

Costa Rica
Electronic Engineering, S.A.
Carretera de Circunvalacion
Sabanilla Av. Novena
P.O. Box 4300-1000, San Jose
TEL: 506-253-3759 or 225-8793
FAX: 506-225-1286

Croatia
Kaltim - Zagreb
Fluke Sls & Serv. Draga 8
41425 Sveta Jana
TEL: 385-41-837115
FAX: 385-41-837237

Denmark
Fluke Danmark A/S, Cust. Supp.
Ejby Industrivej 40
DK 2600 Glostrup
TEL: 45-43-44-1900 or 1935
FAX: 45-43-43-9192

Ecuador
Proteco Coasin Cia., Ltda.
Av. 12 de Octubre 2449 y
Orellana
P.O. Box 17-03-228-A, Quito
TEL: 593-2-230283 or 520005
FAX: 593-2-561980

Egypt
EEMCO
Electronic Equipment Mkting Co.
9 Hassan Mazher St.
P.O. Box 2009
St. Heliopolis 11361
Cairo, Egypt
TEL: 20-2-417-8296
FAX: 20-2-417-8296

Fed. Rep. of Germany
Fluke Deutschland Gmbh
Customer Support Services
Servicestutzpunkt VFN5
Oskar-Messter-Strasse 18
85737 Ismaning/Munich
TEL: 49-89-9961-1260
FAX: 49-89-9961-1270

Fluke Deutschland
(CSS), Servicestutzpunkt VFN5
Meiendorfer Strasse 205
22145 Hamburg
TEL: 49-40-679-6434
FAX: 49-40-679-7653

Finland
Fluke Finland Oy
Sinikalliontie 3, P.L. 151
SF 02631 Espoo
TEL: 358-0-6152-5600
FAX: 358-0-6152-5630

France
Fluke France S.A.
37 Rue Voltaire
BP 112, 93700 Drancy, Cedex
TEL: 33-1-4896-6300
FAX: 33-1-4896-6330

Greece
Philips S.A. Hellenique
Fluke Sales & Service Manager
15, 25th March Street, P.O. Box 3153, 177 78 Tavros Athens
TEL: 30-1-489-4911 or 4262
FAX: 30-1-481-8594

Hong Kong
Schmidt & Co, Ltd. 1st Floor
323 Jaffe Road
Wanchai
TEL: 852-9223-5623
FAX: 852 834-1848

Hungary
MTA MMSZ KFT, Srv. / Gen. Mgr
Etele Ut. 59 -61
P.O. Box 58
H 1502 Budapest
TEL: 361-186-9589 or 209-3444
FAX: 361-161-1021

Iceland
Taeknival HF
P.O. Box 8294, Skeifunni 17
128 Reykjavik
TEL: 354-1-681665
FAX: 354-1-680664

India
Philips India Limited
Band Box House
254 Dr. Annie Besant Road
Bombay 400 025
TEL: 91-22-493-0311
FAX: 91-22-495-0498

Hinditron Services Pvt. Inc.
33/44A 8th Main Road
Raj Mahal Vilas Extension
Bangalore 560 080
TEL: 91-80-334-8266 or 0068
FAX: 91-80-334-5022

Hinditron Services Pvt. Ltd
Hinditron House, 23-B
Mahal Industrial Estate
Mahakali Caves Rd, Andheri East
Bombay 400 093
TEL: 91-22-836-4560, 6590
FAX: 91-22-836-4682

Hinditron Services Pvt. Ltd
Castle House, 5th Floor
5/1 A, Hungerford Street
Calcutta 700 017
TEL: 91-33-400-194

Hinditron Services Pvt. Ltd
204-206 Hemkunt Tower
98 Nehru Place
New Delhi 110 019
TEL: 91-11-641-3675 or 643-0519
FAX: 91-11-642-9118

Hinditron Services Pvt. Ltd.
Field Service Center
Emerald House, 5th Floor
114 Sarojini Devi Road
Secunderabad 500 003
TEL: 91 40-844033 or 843753
FAX: 91-40-847585

Service Centers (cont)

Indonesia
P. T. Daeng Bro, Phillips House
J/n H.R. Rasuna Said Kav. 3-4
Jakarta 12950
TEL: 62-21-520-1122
FAX: 62-21-520-5189 or 62-21-520-5189

Israel
R.D.T Equipment & Sys, Ltd.
P.O. Box 58013
Tel Aviv 61580
TEL: 972-3-645-0745
FAX: 972-3-647-8908

Italy
Fluke Italia S.R.L., CSS
Viale Delle Industrie, 11
20090 Vimodrone (MI)
TEL: 39-2-268-434-203 or 4341
FAX: 39-2-250-1645

Japan
Fluke Corp., Sumitomo Higashi
Shinbashi Bldg.
1-1-11 Hamamatsucho
Minato-ku, Tokyo 105
TEL: 81-3-3434-0188 or 0181
FAX: 81-3-3434-0170

Kenya
Walterfang
P.O. Box 14897
Nairobi, Kenya
TEL: 254-2
FAX: 254-2

Korea
B&P International Co., Ltd.
Geopung Town A-303
203-1 Nonhyun-Dong
Kangnam-Ku
Seoul 135-010
TEL: 82 12 546-1457
FAX: 82 12 546-1458

IL MYOUNG, INC.
Youngdong P.O. Box 1486
780-46, Yeogsam-Dong
Kangnam-Ku, Seoul
TEL: 82 2 552-8582-4
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FAX: 965-4847244

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Lebuhraya Batu Lancang
Taman Seri Damai
11600 Jelutong Penang
TEL: 60-4-657-9584
FAX: 60-4-657-0835

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C.P. 03100, Mexico D.F.
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FAX: 52-5-687-8695

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FAX: 31-40-644321

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FAX: 64-9-849-7814

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Philips Projects Centre
Resident Delegate / PMB 80065
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FAX: 234-1-262-0631

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N-0601 Oslo
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FAX: 47-22-653407

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Islamic Cham. of Commerce
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Clifton, Karachi-75600
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FAX: 92-21-577-0348

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S.A., JR. Pumacahua 955
Lima 11
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FAX: 51-14-31-0707

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Metro Manila 1502
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FAX: 63-2-721-0491 or 700-709

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60 188 Poznan
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FAX: 48-61-682256

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70778 Bucharest - I
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FAX: 40-1-659-4468

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FAX: 7-95-212-3838

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Pestas Prof. Elektr. Sist. Tic. V
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FAX: 263-4-729970

Chapter 5
Schematic Diagrams

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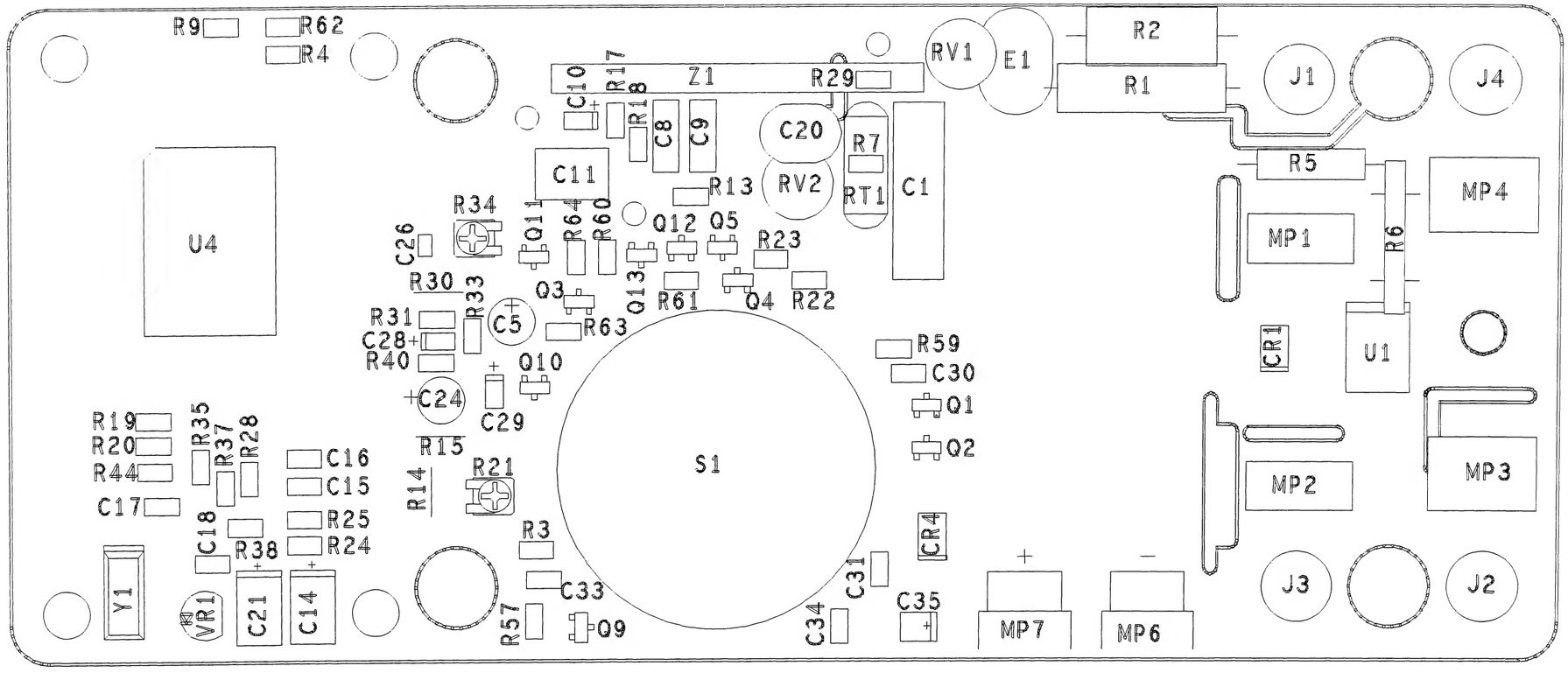

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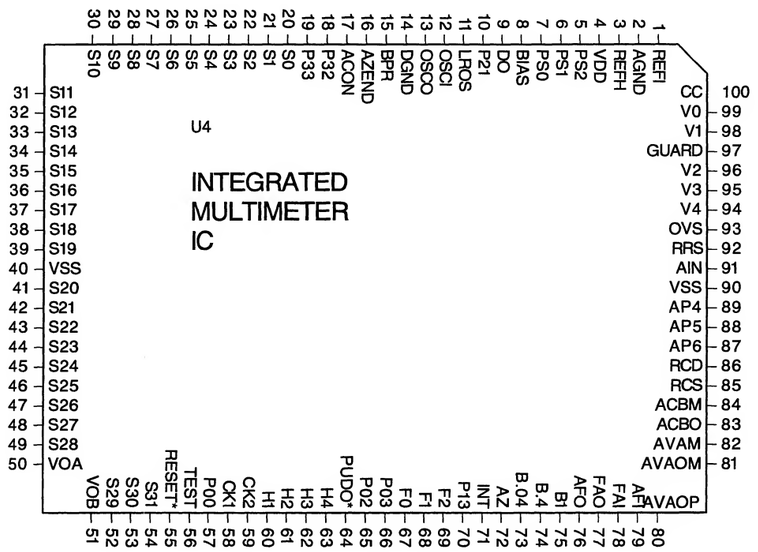
Figure 5-1. A1 Main PCA

NOTES: UNLESS OTHERWISE SPECIFIED:

2. ALL CAPACITANCES ARE IN MICROFARADS +/- 20%.

3. ALL RESISTANCES ARE IN OHMS. ALL RESISTORS ARE 1/8W, 5%, CERMET.

4 R1 IS A FUSIBLE RESISTOR. TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.



Component Type Abbreviation Code			
Sym	**Capacitor**	**Sym**	**Resistor**
M	Mylar/Polyester	MG	Metal Glaze
C	Ceramic	WW	Wire Wound
T	Tantalum	MF	Metal Film
PC	Poly Carbonate		
PP	Polypropylene Film		

Reference Designation			
Last Used		No t Used	
R	64	R	8, 10, 11, 12, 16, 26, 27, 32, 36, 39, 41-43, 45-56, 50.
C	35	C	2, 3, 4, 6, 7, 12, 13, 19, 22, 23, 25, 27, 32.
BT	1		
U	5	U	2, 3
J	4		
LS	1		
Q	13	Q	6, 8
S	2		
TP	6		
CR	4	CR	2, 3
RT	1		
Y	1		
VR	1		
Z	1		
E	1		

S1 Keys

Position	Function
1	Off
2	VAC
3	Hz
4	VDC
5	mVDC
6	OHMS/Cap
7	Cont/Low OHMS/DT
8	Current

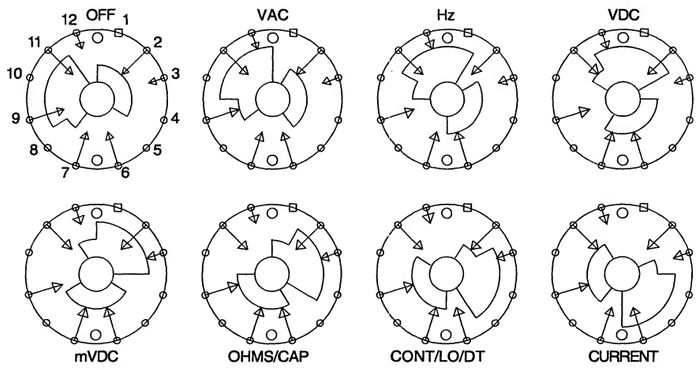


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Figure 5-1. A1 Main PCA (cont)

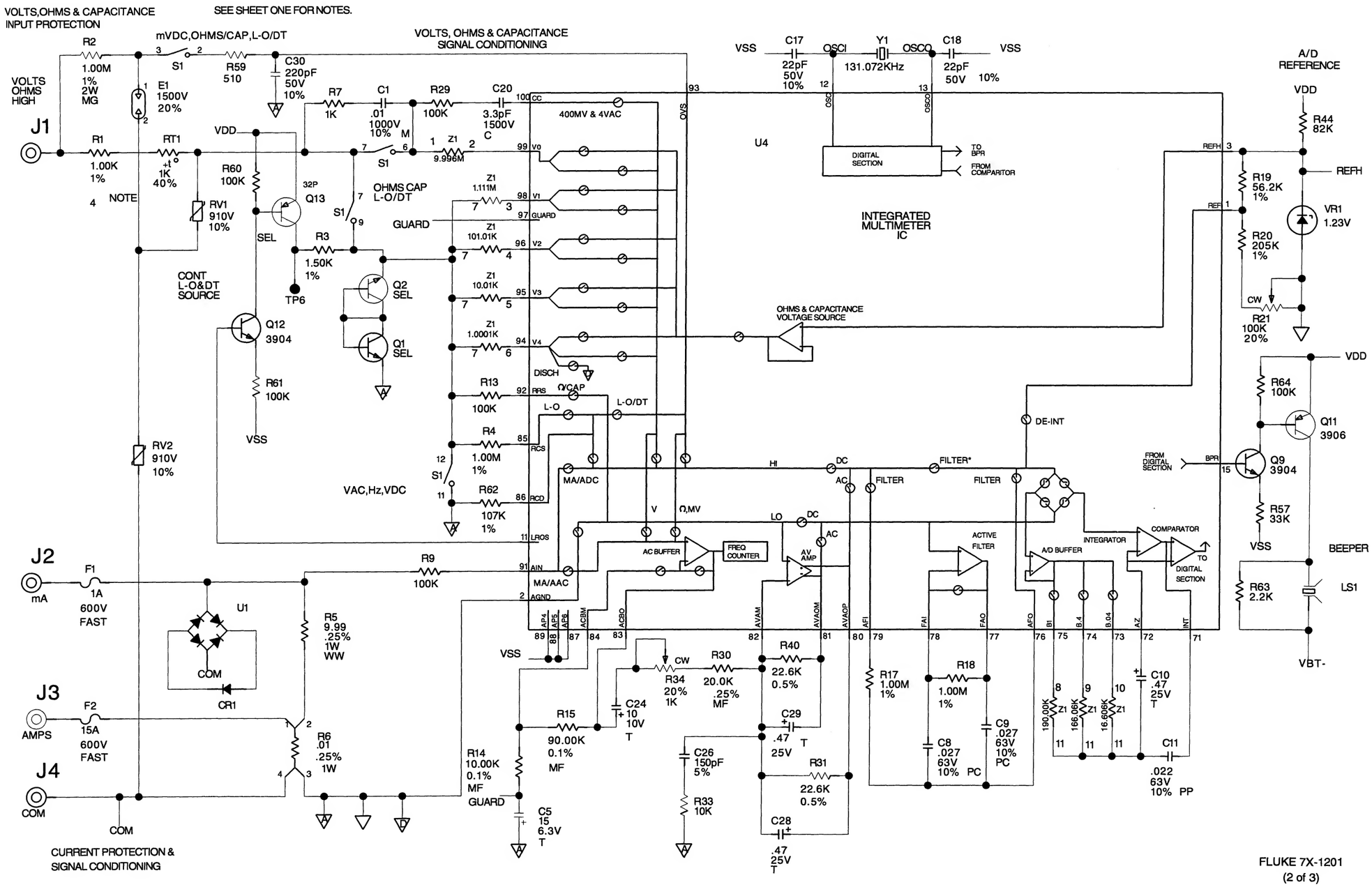


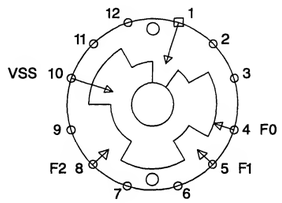
Figure 5-1. A1 Main PCA (cont)

SEE SHEET ONE FOR NOTES.

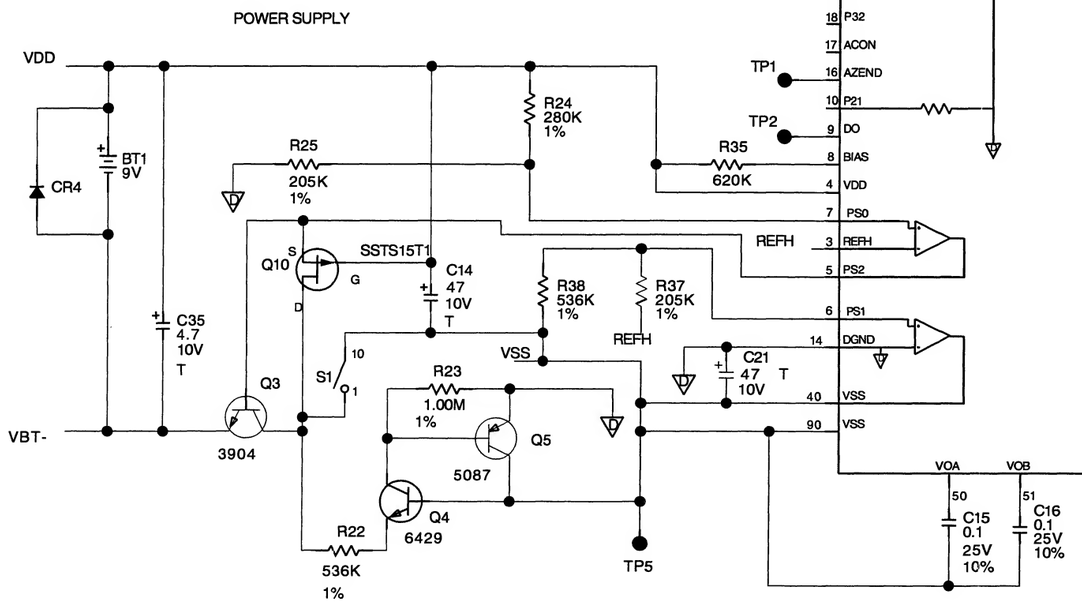
S1 KEY

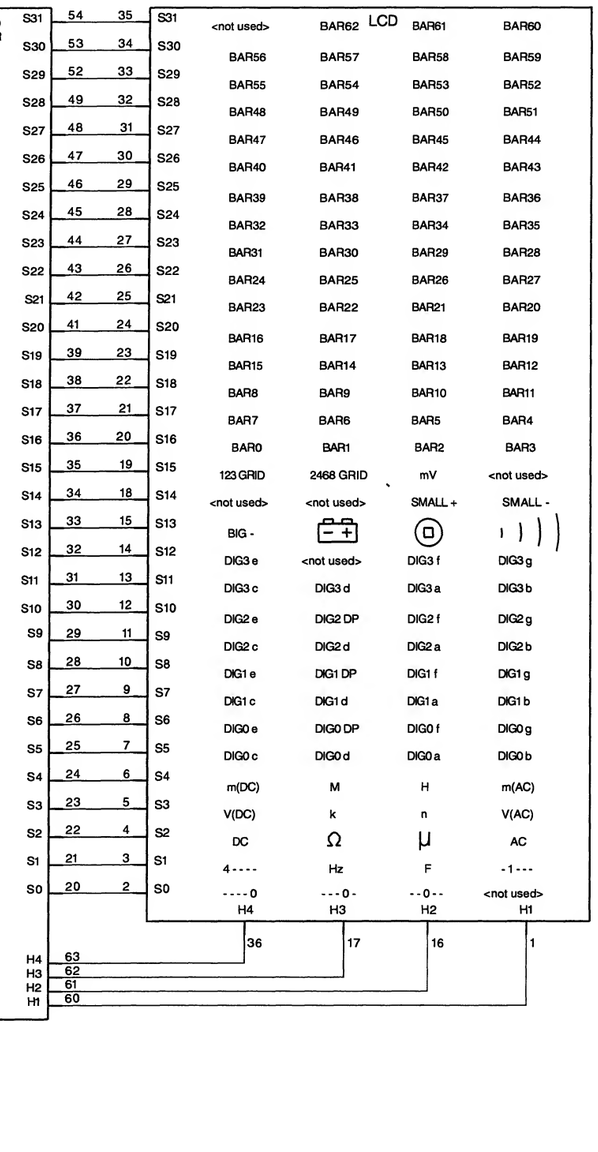
POSITION	FUNCTION	FUNCTION CODE* F2 F1 F0
1	OFF	- - -
2	VAC	0 0 0
3	Hz	0 0 1
4	VDC	1 1 1
5	mVDC	0 1 1
6	OHMS/CAP	0 1 0
7	CONT,LOW OHMS/DT	1 0 0
8	CURRENT	1 0 1

*1 = COMMOM
0 = VSS



OFF POSITION





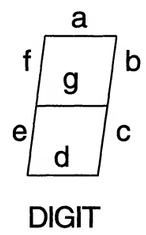


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Figure 5-1. A1 Main PCA (cont)